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A COMPARATIVE STUDY OF METHODS OF DETERMINING THE MOISTURE CONTENT OF CHEDDAR CHEESE

I. THE MODIFIED MOJONNIER AND OLIVE OIL METHODS*

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INTRODUCTION

The chief disadvantage of the majority of methods which have been developed for the determination of moisture in cheddar cheese is the time required for operation. For example, 24 hours of heating at 100° C. is recommended for the drying oven method when a 2–3 gram sample of cheese is used (1), whereas the steam pressure oven method (2) and the official method as outlined by the Association of Official Agricultural Chemists (3) require about 2.5 and 4.5 hours respectively. The Mojonnier moisture test for cheese (4) requires less time than these other methods but the equipment is more elaborate and expensive than can be afforded by many cheese factories.

For years, little success was obtained in the development of a rapid, simple, open-flame method for the determination of moisture in cheese similar to the method ordinarily used for butter. Troy (5) early concluded such a procedure gave unsatisfactory results because, first, the cheese when heated swelled and sputtered badly, which brought about loss of the sample, and secondly, constituents other than moisture were apt to be driven off due to the high temperature of heat and the fact that the cheese stuck to the bottom of the pan. The result of these conclusions was the development of a fairly rapid method by this investigator (4) (5). This method consists briefly in the heating of a 5 gram sample in a double-walled copper cup at a temperature of about 140–145° C. for 50 minutes. The space between the double walls of the cup is filled with oil and the heating is accomplished by means of an alcohol or gas flame. The loss of weight indicates the moisture of the sample.

During 1933, the author's attention was called to the fact that at least one cheese plant in Michigan was determining the moisture content of cheese by use of an open flame method in which olive oil was placed in the

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pan with the cheese to prevent burning and sputtering. Preliminary work on a study of this moisture test was carried out shortly thereafter to determine the possible merits of the procedure. Later, in 1935, Dittrich (6) recommended a similar rapid moisture test for process cheese, and with the exceptions of using a 5-gram sample, and placing 10 cc. of olive oil in the moisture dish with the sample, the procedure was the same as for the open flame method for butter.

Oil methods similar to the above have been utilized by other workers, but no published data concerning them are available. Sammis (7) states that such a test has been used in warehouses and in schools for cheese-makers throughout Wisconsin, and recommends the use of an aluminum cup 2 inches in diameter and 3 inches in height for the moisture determination, which he believes is deep enough to prevent spattering if any occurs. Olive oil was found to be satisfactory for this test and to lose no weight when heated alone over a small flame. Approximately 30 minutes was found to be required for the test, and results agreed well with the oven tests. A similar moisture test is reported by Greer (8) with cottonseed or boiled linseed oil being used in place of the olive oil. The heating of the sample was carried out on a hot plate, 30 to 45 minutes being required for the heating period. The results were found to be within one per cent of those obtained by using the regular oven moisture test.

Since no published investigational work is available regarding the practicability and accuracy of an open flame test involving the use of olive oil and of factors which may influence its accuracy, a study of such a method was made. The results secured by analyzing cheddar cheese for moisture by this method were compared to results secured on the same samples by a modified Mojonnier method.

EXPERIMENTAL

The cheese sample which was to be analyzed was trimmed free of the rind and of dried surfaces and then was finely chopped and placed in a glass jar with a tightly fitting metal screw cap. The sample was kept in a refrigerator, being brought out only for a period sufficiently long to permit weighing of the cheese for the moisture determination.

The Mojonnier method, with which the olive oil results were compared, was carried out according to recommendations (4) with one minor modification. This modification was made after preliminary trials showed the results to not differ appreciably from those secured by the use of the regular Mojonnier procedure. The regular Mojonnier procedure requires a glass rod to be used to break up the particles of cheese prior to the drying of the cheese on the hot plate. In this study no glass rod was used, but instead approximately 3 cc. of water was added to the sample. The sample was then heated slowly on the hot plate with continuous, gentle shaking until the

particles were melted and dispersed. From this point on, the sample was treated according to the regular procedure.

Since no information was available as to the most desirable procedure for the olive oil method, the procedure for this method was varied to some extent at first to determine the amount of oil and the size of sample which would give the most satisfactory results. With these exceptions, the olive oil test was conducted as follows:

The desired amount of high grade olive oil was measured into an aluminum dish, the dishes used being the same as those used for fat determination with the Mojonnier apparatus, *i.e.*, about 5 cm. in height and about 8 cm. in diameter. The oil was heated in the dish over a small gas flame until it began to fume slightly to make certain it was free from moisture. The olive oil used was found to contain little or no moisture. The pan and dried oil were cooled and then balanced on the right hand platform of a Torsion butter-moisture scale. The desired amount of finely chopped cheese was weighed carefully and allowed to become covered with the oil by gently tilting the pan. The cheese was dried by heating the pan and its contents over a low gas flame. During the heating the pan was gently shaken to keep the cheese from sticking to the bottom of the dish and to permit more efficient evolution of moisture. The heating and shaking was carried on until bubbling ceased. The pan and its contents were cooled and weighed, and the reading secured on the balance beam was corrected to the basis of a 10 gram sample.

Variations in Method: Variations in the size sample and in the amount of olive oil to use were studied at first to determine the procedure which would give the greatest constancy in results. Three different variations were tried. One procedure, Method A, consisted of using a 5 gram sample and 20 cc. of olive oil; the second, Method B, consisted of using a 5 gram sample and 10 cc. of olive oil and the third, Method C, consisted of 2.5 grams of cheese and 10 cc. of oil. Other than these differences, the procedures were the same. No particular effort was made to weigh exactly the same size sample each time. However, care was used so that the weight of the sample did not differ more than 0.25 gram from the size desired.

A total of 20 trials were carried out in which comparisons were made between these three variations in the procedure. The results are shown in Table 1. These data indicate that on the basis of averages, Method A give closer duplicate checks than the other methods. The average difference between duplicate determinations for Method A was $0.14 \pm .01$ per cent; for Method B, $0.23 \pm .03$ per cent; and for Method C, $0.55 \pm .07$ per cent. When the procedure for Method A was followed, 17 or 85 per cent of the trials gave differences between duplicates not exceeding 0.20 per cent. In comparison, only 9, or 43 per cent of the 21 trials using Method B, and 5 or 30 per cent of the 15 trials using Method C fell within this class.

TABLE 1

*The influence of variations in the olive oil procedure of the uniformity of duplicate determinations**

SAMPLE NO.	DIFFERENCE BETWEEN DUPLICATE TESTS		
	Method A	Method B	Method C
1	0.00	0.06	0.20
2	0.20	0.40	0.91
3	0.05	0.34	0.64
4	0.01	0.36	0.60
5	0.13	0.21	0.22
6	0.11	0.27	0.11
7	0.15	0.21	0.70
8	0.28	0.04	.....
9	0.18	0.16	1.41
10	0.19	0.11	.....
11	0.04	0.27	0.31
12	0.16	0.21	.....
13	0.06	0.04	.....
14	0.21	0.76	0.02
15	0.07	0.29	1.36
16	0.16	0.42	0.71
17	0.16	0.06	0.20
18	0.20	0.24	0.40
19	0.15	0.11	0.47
20	0.12	0.03	0.13
21	0.32	0.16	1.10
Average difference between duplicates	$0.14 \pm .01$	$0.23 \pm .03$	$0.56 \pm .07$

* Procedure for all methods identical with exceptions that Method A used 20 cc. of oil and 5 grams of the sample; Method B, 10 cc. of oil and a 5 gram sample; and Method C, 10 cc. of oil and a 2.5 gram sample.

These trials point out the value of using sufficient oil to at least fairly well cover the cheese sample. The use of too small a volume of oil permitted excess sticking and spattering of the sample and cause appreciable errors in the moisture determinations. There was no apparent need, however, for excessively large amounts of the oil. The amount of oil to use would be governed largely by the size of the sample and the diameter of the moisture dish. Smaller amounts of oil could without question be used satisfactorily in moisture dishes of small diameters. However, in the trials of this experiment, because of the greater constancy of the results secured when Method A was used, this procedure was selected as the one to be subjected to further study.

Difficulties Encountered. Several difficulties were experienced in securing proper moisture analysis of cheese samples by any of the above olive oil methods. In most trials, the cheese stuck more or less badly to the bottom

of the moisture dish during heating. This sticking occurred regardless of the amount of olive oil, although it was more noticeable in methods B and C. The dish appeared to be one source of trouble since the use of new pans largely eliminated the sticking of the cheese in Method A and lessened it to a marked degree in Methods B and C. In addition to the sticking of the cheese during the heating process, the cheese also lumped or clumped into one mass, and it seemed practically impossible to prevent such lumping. This lumping in itself would appear to prevent complete drying of the cheese.

Another major difficulty encountered with the olive oil tests was that of spattering. This spattering was noted only when certain samples were heated, and once it occurred it was not easily remedied. The spattering was noticeable immediately at the start of the heating period and was accompanied by considerable crackling and snapping. The usual result was the loss of some of the material from the dish, which, consequently, resulted in errors. As a general rule, if spattering occurred, it could not be prevented by more careful or slower heating. Because of large errors which naturally resulted from the heating of samples showing the tendency to spatter, it was decided to eliminate all data relative to such samples from consideration until some modification was devised to prevent the occurrence of the difficulty. Therefore, the 31 trials of the olive oil test reported in Tables 2 and 3 are the results obtained from non-spattering samples.

Differences between Duplicates: A measure of the constancy or consistency of any method of analysis may be shown by the closeness of the checks between duplicate determinations carried out by this method. The variations between duplicate determinations by the modified Mojonnier and the olive oil method are given in Table 2. The averages show little differences between the two methods with the Mojonnier method averaging $0.30 \pm .03$ per cent between duplicates and the olive oil method averaging $0.26 \pm .03$ per cent. The olive oil method's average difference is somewhat higher than shown for Method A in Table 1, but this is at least partially due to abnormally large differences between the duplicates determinations secured on samples 18 and 24. Fourteen, or 45 per cent of the Mojonnier determinations, varied 0.2 per cent or less between duplicates, whereas 24 or approximately 77 per cent varied less than 0.5 per cent. Of the 28 samples analyzed by the olive oil method, 18 or approximately 64 per cent varied 0.2 per cent or less, whereas 26 or about 93 per cent showed variations no greater than 0.5 per cent.

Comparison of Modified Mojonnier and Olive Oil Methods: The results of the analysis of thirty-one samples of cheese by the modified Mojonnier and olive oil methods are given in Table 2. The results show close agreements between the two methods, with the olive oil method giving results averaging about 0.3 per cent higher than those secured by the Mojonnier

TABLE 2

The differences between duplicate determinations of the moisture content of cheese by the modified Mojonnier and the olive oil methods

SAMPLE NO.	DIFFERENCE BETWEEN DUPLICATES PER CENT	
	Modified mojonnier	Olive oil
1	0.64	0.00
2	0.09	0.20
3	0.20	0.05
4	0.24	0.01
5	0.11	0.13
6	0.15	0.11
7	0.63	0.15
8	0.33	0.27
9	0.64	0.21
10	0.22	0.12
11	0.58	0.18
12	0.28	0.18
13	0.50	0.04
14	0.10	0.15
15	0.52	0.06
16	0.04	0.10
17	0.91	0.42
18	0.03	1.47
19	0.37	0.21
20	0.54	0.07
21	0.24	0.16
22	0.44	0.16
23	0.24	0.41
24	0.01	1.21
25	0.08	0.39
26	0.39	0.12
27	0.02	0.32
28	0.15	0.24
29	0.14	.....
30	0.16	.....
31	0.19	.....
Avg.	$0.30 \pm .03$	$0.26 \pm .03$

procedure. The average of the differences between individual determinations by the two methods shows the olive oil method to give values differing from the Mojonnier results by $0.38 \pm .04$ per cent. Twenty-six of the thirty-one determinations gave higher results by the oil method.

Modification of the Olive Oil Method. As previously stated, considerable difficulty was experienced during the heating of certain samples when following the olive oil procedure, because of the samples spattering and throwing a portion of the material from the dish, and also because of the samples sticking to the bottom of the pan.

The results appearing in the preceding tables show great possibilities for

the olive oil method, providing no spattering or sticking occurs. In view of this, efforts were made to modify the method to eliminate at least a portion of the difficulties encountered when the regular procedure is followed.

The possibilities of using sodium chloride with the olive oil was suggested and trials were conducted to determine its influence. About one gram of the salt was added to the olive oil and the mixture dried over the flame as before. Variations in the amount of salt apparently did not influence the results. The samples analyzed were those which, in many cases, did not lend themselves to analysis by the regular olive oil method. The

TABLE 3

The moisture content of Cheddar cheese when determined by the modified Mojonnier and olive oil methods

SAMPLE NO.	MODIFIED MOJONNIER METHOD	OLIVE OIL METHOD (A)	
	Moisture per cent	Moisture per cent	Difference from Mojonnier per cent
1	36.54	36.60	+0.04
2	34.86	34.90	+0.04
3	33.82	34.31	+0.49
4	33.35	33.85	+0.50
5	33.82	34.14	+0.32
6	33.66	33.75	+0.09
7	33.96	34.03	+0.07
8	35.75	35.72	−0.03
9	30.70	29.99	−0.71
10	33.52	33.87	+0.35
11	30.48	30.29	−0.19
12	31.55	31.73	+0.18
13	43.82	44.02	+0.20
14	44.12	44.05	−0.07
15	43.34	43.50	+0.16
16	42.49	42.76	+0.27
17	41.44	41.96	+0.52
18	43.36	43.77	+0.41
19	37.95	38.71	+0.76
20	35.92	36.43	+0.51
21	36.35	36.75	+0.40
22	32.94	32.78	−0.16
23	33.04	33.54	+0.50
24	33.37	34.02	+0.65
25	37.12	37.28	+0.16
26	39.90	40.28	+0.38
27	34.11	34.76	+0.65
28	36.04	36.46	+0.42
29	38.60	40.24	+1.64
30	34.68	35.23	+0.55
31	39.50	39.75	+0.25
Avg.	36.45 ± .48	36.75 ± .49	0.38 ± .04

procedure, with the exception of adding the salt, was the same as followed previously. A marked improvement in the ease of drying the samples was immediately observed. In the first place, the salt prevented spattering of the sample in practically all cases. The only spattering which was observed occurred when 10 cc. of oil were used instead of 20 cc. Secondly, the salt prevented the cheese from sticking to the bottom of the pan, irrespective of the condition of the pan itself. Thirdly, the salt prevented the cheese from gathering in one large lump during the heating, as it had in most cases in which olive oil alone was used. The cheese particles remained in small balls in the olive oil-salt mixture throughout the drying period, and thus, from all appearances, were in condition to facilitate more rapid and more complete drying.

Variations in Method. Since the use of salt corrected the major defects of the olive oil method, it appeared desirable to determine the accuracy of a modified procedure (designated as modified oil method) in which salt was used. The first step taken was to determine again the comparative constancy of the three different procedures heretofore listed as Methods A, B, and C, which were in all cases modified by the addition of about a gram of salt. As before, Method A consisted of using 20 cc. of oil with 5 grams of cheese; Method B, 10 cc. of oil with 5 grams of cheese; and Method C, 10 cc. of oil with 2.5 grams of cheese. The comparison of the results of these methods is given in Table 4.

The results in this table again show a somewhat greater accuracy of Method A over the other olive oil methods on the basis of variation between duplicate samples, the average variation for this method being $0.20 \pm .03$ per cent, as compared to $0.27 \pm .03$ per cent for Method B, and $0.47 \pm .11$ per cent for Method C.

A closer study of the results in this table show that 12, or 63.2 per cent of the variations between duplicates in modified olive oil Method A were not greater than 0.2 per cent, whereas, on the same basis, the values for olive oil Method B were 9 or 52.9 per cent; and for Method C, 6 or 42.9 per cent. The greatest variation in olive oil Method A was less than 0.6 per cent, whereas for Methods B and C the variations were larger than 0.8 per cent. In no case was spattering observed in following the procedure as outlined for Method A of the modified oil test, although it occurred to such an extent on Samples 1 and 16 when Method B was used as to render the moisture determination by this method impractical.

Table 4 also shows that 9 of the 20 samples analyzed in these trials did not lend themselves to moisture analysis by the regular olive oil procedure, whereas they were analyzed without difficulty by Method A of the modified procedure. This emphasizes the value of the salt modification if the olive oil method is to be generally adaptable.

Comparison of Modified Oil and Mojonnier Methods: The average values

TABLE 4

The influence of variations in the modified olive oil procedure on the uniformity of duplicate determinations

SAMPLE NO.	DIFFERENCE BETWEEN DUPLICATES PER CENT		
	Method A	Method B	Method C
1*	0.57	**	2.64
2	.....	0.82	1.43
3*	0.60	.....	.....
4	0.26	0.10	0.55
5	0.32	0.74	0.24
6	0.17	0.13	.....
7	0.14	0.16	0.05
8	0.21	0.30	0.30
9*	0.07	0.32	0.07
10*	0.16	0.10	.....
11	0.19	0.12	.....
12	0.10	0.28	0.21
13	0.24	0.17	0.13
14*	0.13	0.21	0.02
15	0.10	0.39	.....
16	0.07	**	0.28
17	0.02	0.30	0.12
18*	0.03	0.20	0.20
19*	0.05	0.15	0.14
20*	0.46	0.07	0.61
Average difference	0.20 ± .03	0.27 ± .03	0.47 ± .12

* Sample spattered badly when heated in olive oil which did not contain added salt. Such samples did not permit accurate moisture determinations by the regular olive oil method.

** Sample spattered while being heated and some material was lost from the dish.

of 20 moisture determinations made by the modified oil method (A), and by the modified Mojonnier method are given in Table 5. The average moisture content of the samples by the Mojonnier procedure was 36.06 ± .52 per cent and by the modified olive oil method was 36.61 ± .53 per cent, a difference of 0.55 per cent. Nineteen of the twenty trials gave higher values by the modified olive oil method with the average of all differences being 0.56 ± .05 per cent.

DISCUSSION AND SUMMARY

This study was carried out to determine the desirability of using a so-called olive oil test as a means of determining the moisture content of Cheddar cheese, and to modify it if necessary so that the results by this method would be accurate enough for all practical purposes.

Preliminary results, secured by using variations in the olive oil procedure, showed more constant values could be obtained if the sample weighed approximately 5 grams and approximately 20 cc. of olive oil were used. Wider variations between duplicate determinations were obtained if

TABLE 5

The moisture content of Cheddar cheese when determined by the modified Mojonnier and modified olive oil methods

SAMPLE NO.	MODIFIED MOJONNIER METHOD	MODIFIED OLIVE OIL METHOD (A)	
	Moisture per cent	Moisture per cent	Difference from Mojonnier per cent
1	37.61	38.07	+0.46
2	35.92	36.76	+0.84
3	36.35	37.17	+0.82
4	32.94	33.10	+0.16
5	33.04	33.12	+0.08
6	33.37	34.48	+1.11
7	37.12	37.45	+0.33
8	38.26	38.89	+0.63
9	39.90	40.84	+0.94
10	40.29	40.60	+0.31
11	34.11	34.83	+0.72
12	34.54	34.85	+0.31
13	36.04	36.39	+0.35
14	38.60	39.89	+1.29
15	34.68	34.84	+0.16
16	39.21	39.61	+0.40
17	41.06	41.91	+0.85
18	39.50	39.77	+0.27
19	32.64	32.55	−0.09
20	26.08	27.07	+0.99
Avg.	36.06 ± .52	36.61 ± .53	0.56 ± .05

10 cc. of oil were used with either a 5 or a 2.5 gram sample of cheese. This was due probably to the fact that insufficient oil was used to completely cover the cheese during the heating.

Thirty-one non-spattering samples of Cheddar cheese were analyzed for moisture by the olive oil method and by the modified Mojonnier method, with the oil method giving results averaging approximately 0.3 per cent higher than those secured by the Mojonnier procedure.

Many samples of cheese, however, spattered too badly upon healting in the olive oil to permit accurate moisture determinations. In fact, approximately 30 to 40 per cent of the samples encountered possessed this spattering tendency under the conditions of this experiment. In addition, practically all of the cheese samples, during heating, lumped together and stuck to the bottom of the pan. When a small amount of sodium chloride, approximately one gram, was added to the oil, the cheese particles did not clump together or stick to the bottom of the pan, nor did the cheese samples encountered in this study spatter upon heating.

The oil moisture test, modified by the use of the salt, gave results averaging approximately 0.5 per cent higher than those secured by the Mojonnier procedure. These higher values may have been due to the fact that the

particles of cheese did not clump or stick during the heating, thus permitting more efficient drying, and secondly to the dehydrating action of the salt itself. That the action of the salt was not merely physical was proved by the substitution of dry sand. The sand did not prevent sticking or spattering of the cheese.

It might be concluded, therefore, that in regard to its general applicability the modified olive oil test appears to be the most logical choice since it does not appear to be generally affected by samples with spattering characteristics or by the condition or type of moisture pans. Recognition should be given to the fact that the results by this method are likely to be slightly high in comparison to those secured by the regular olive oil and Mojonnier methods, although they appear accurate enough for all practical purposes.

One of the chief advantages of the open flame oil method is its rapidity of operation. A moisture determination by this procedure can be completed in approximately 20 minutes, with only 5–7 minutes actually being required for the heating period.

The results of this study dealing with the olive oil methods present possibilities for further investigational work. First, there is need for a comparison of results secured by the modified method with those obtained by a recognized accurate method since the Mojonnier method for cheese has not been officially adopted as a reliable standard for comparison with other procedure. In addition, there is a need for knowledge as to other oils which may be substituted for the olive oil, and also for information as to other materials which may be used to supplant the salt in the modified procedure.

ACKNOWLEDGMENT

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THE ELECTROKINETIC POTENTIAL OF MILK FAT

III. RELATION TO THE FAT GLOBULE "MEMBRANE"[1]

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The electrokinetic potential in any system is determined by the conditions present at the interface. This has been demonstrated by Abramson (1) who shows that quartz particles suspended in a liquid exhibit certain electrokinetic properties but when the surface of the quartz is covered with an adsorbed layer of a material such as gelatin the particles take the properties of the adsorbed layer. This fact indicates that studies of electrokinetic potentials might well be expected to yield information concerning the nature of the interface between the fat surface and the milk plasma.

HISTORICAL

The nature and distribution of the materials adsorbed on fat globules in milk have been subjects of investigation for many years. Ascherson (2) in 1840 suggested that a protein material formed a "skin" around the globules which he called "Haptogen Membrane." Storch (3) believed that the globules were surrounded by a mucoid substance which he called a "Slimmen-membran." Abderhalden and Völtz (4) analyzed the fat globule membrane material and secured variable results. They came to the conclusion that it contained a mixture of proteins. Titus, Sommer, and Hart (5) obtained membrane material by washing cream and found it to compare in composition and reactions with casein. Palmer and Samuelsson (6) called attention to the fact that the membrane contained phospholipids as well as proteins. Since then Palmer and his associates have published a series of papers (7, 8, 9, 10) covering researches on the membrane material isolated from washed cream and its relation to churning. It is generally accepted that the material present at the fat-globule/milk plasma interface is a mixture of proteins and phospholipids.

EXPERIMENTAL

Some of the results previously reported (11, 12) suggested the possibility of obtaining information concerning the composition of the fat globule membrane by altering the membrane and studying the effects of the alteratoins by means of electrophoretic measurements. Two general methods were used

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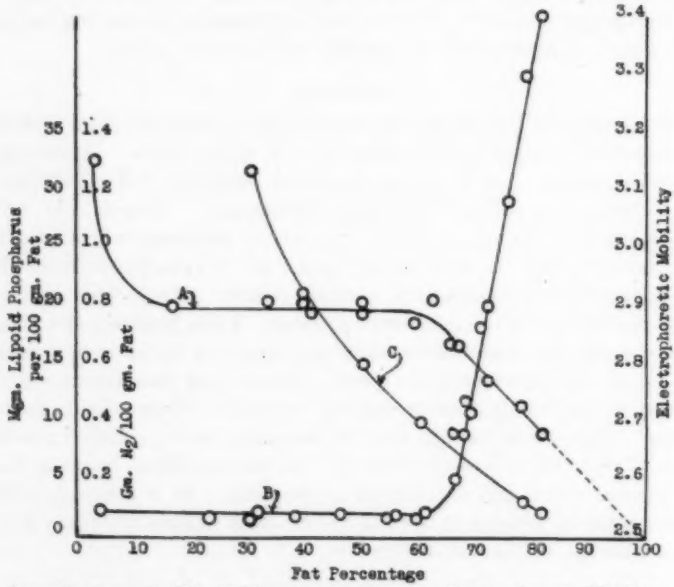
to alter the membrane; progressive removal of the membrane from the fat globule surface by centrifugal separation of milk into creams of varying fat content or by washing cream; and by reconstructing a membrane by the adsorption of known milk constituents on the surface of the fat.

Separation Studies

Creams ranging from twenty to eighty per cent fat were obtained by separation of raw milk. Electrophoretic measurements, lipoid phosphorus and nitrogen determination were made on the different creams. The electrophoretic measurements were made according to the procedure previously described (11). Lipoid phosphorus determinations were made by the method adapted by Smith (13). Nitrogen was determined by the Kjeldahl method.



Legend: Curve A—Lipoid Phosphorus; Curve B—Electrophoretic Mobility; Curve C—Nitrogen/100 gm. Fat.

FIG. 1. THE RELATION OF FAT PERCENTAGE TO ELECTROPHORETIC MOBILITY, LIPOID PHOSPHORUS, AND NITROGEN CONTENT OF CREAM.

The results are shown in Figure 1. The lipoid phosphorus values coincide with those found by Perlman (14) in a study covering the same fat percentage range.

To study the readsorption of milk constituents, a series of samples were prepared for an electrophoretic study in which skim milk from each sample was added to cream diluted so that each sample contained the same concen-

tration of milk solids-not-fat. The electrophoretic mobilities of the fat globules in creams of varying fat contents before and after readsorption of milk constituents is shown in Table 1.

TABLE 1
The effect of separation and readsorption of milk plasma components on electrophoretic mobility

FAT PERCENTAGE	MOBILITY μ/SEC/V/CM.	
	Before adding skim milk	After adding skim milk
3.7	2.56	.....
17.5	2.58	2.59
23.0	2.57	2.58
25.0	2.55	2.55
29.0	2.57	2.57
31.0	2.58	2.55
37.0	2.57	2.57
46.0	2.56	2.55
52.5	2.57	2.56
54.0	2.58	2.58
56.7	2.57	2.55
59.4	2.57	2.57
60.0	2.57	2.55
64.0	2.61	2.56
66.5	2.70	2.57
68.5	2.72	2.55
69.3	2.79	2.55
72.0	2.87	2.54
75.0	3.04	2.58
79.0	3.27	2.56
81.0	3.35	2.55

Washed Cream Studies

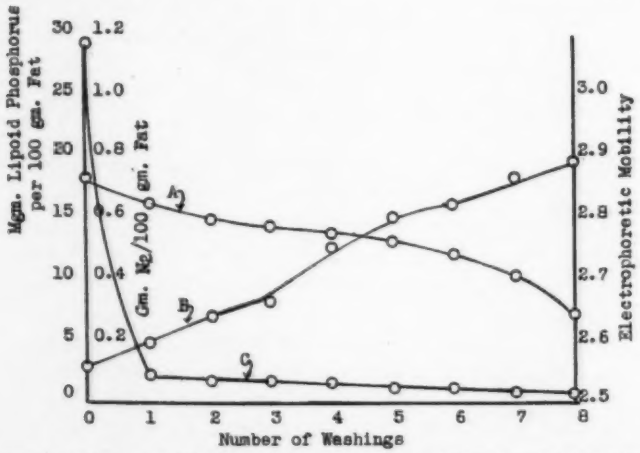
Cream was washed by diluting with three volumes of distilled water and reseparating after each dilution by means of a Sharples supercentrifuge. This procedure was repeated seven times. Samples were taken after each washing for electrophoretic, lipoid phosphorus, and nitrogen determinations. The values obtained are shown in Figure 2. Similar results were obtained by centrifuging in an International SB Centrifuge using glass tubes showing that the mechanical action of the centrifuge was not important in removing the membrane from the fat globules.

Synthetic Milk Studies

It seemed desirable to study the adsorption of known milk constituents on the surface of milk fat. To do this it was necessary to prepare synthetic milks. Solutions of milk salts, lactose, and a casein sol were prepared according to the method of Clark (15). Butter oil was prepared by centri-

fuging and filtering unsalted butter until it was phosphorus-free. Milk phospholipids were prepared by extracting washed cream buttermilk with ethyl alcohol and ethyl ether and precipitating the phospholipids with acetone. The fat-free phospholipid had a phosphorus content of 3.87 per cent, contained 1.73 per cent nitrogen and its isoelectric point was pH 2.0. The phosphorus and nitrogen contents correspond to those of a lecithin-like compound with a molecular weight of approximately 800.

Pure butter oil was emulsified in each of the following three media to result in a fat content of 0.6 per cent: (1) recently boiled distilled water, (2) a sol containing 3 per cent casein, and (3) a sol containing 0.5 per cent phospholipids. The isoelectric points in each of the three media were determined in a M/15 acetate buffer. The fat globules were isoelectric at pH 3.3 in distilled water, at pH 4.6 in the casein sol, and at pH 2.0 in the phospholipid sol. In the casein and phospholipid sols the isoelectric points correspond to the isoelectric points of the stabilizing material, but in neither case does the isoelectric point correspond to that of normal milk fat at pH 4.3.



Legend: Curve A—Lipoid Phosphorus; Curve B—Electrophoretic Mobility; Curve C—Nitrogen/100 gm. Fat.

FIG. 2. THE EFFECT OF WASHING CREAM UPON THE ELECTROPHORETIC MOBILITY, LIPOID PHOSPHORUS, AND NITROGEN CONTENT.

The addition of milk salts, lactose solution, and phospholipid sol to the dispersion of butter oil in the casein sol did not change the isoelectric point from pH 4.6. However, the addition of the casein sol, milk salts, and lactose solution to the dispersion of butter oil in the phospholipid sol shifted the isoelectric point to pH 4.3, the isoelectric point of the fat globules in normal milk. The results are shown in Figure 3.

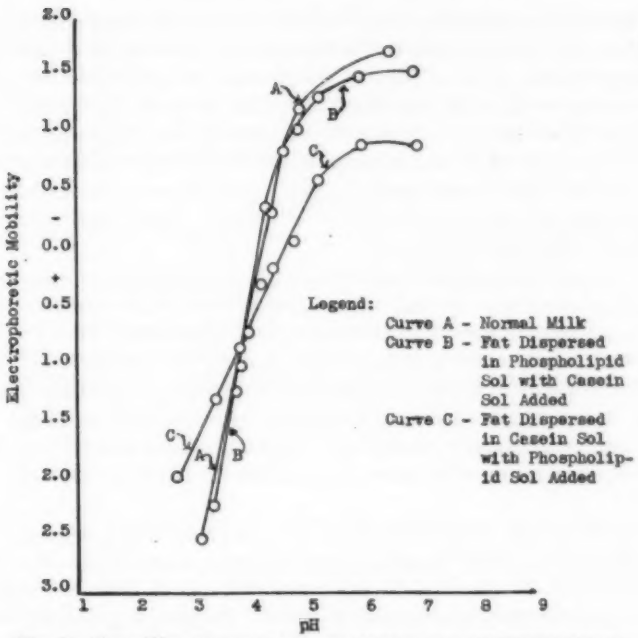


FIG. 3. THE pH MOBILITY CURVES OF NORMAL AND SYNTHETIC MILKS.

DISCUSSION

The data in Figure 1 show that the electrophoretic mobilities and lipoid phosphorus values per unit of fat in creams containing from 17 per cent milk fat to 60–65 per cent milk fat were constant. Above this fat concentration the mobilities increase with increasing fat content, and the amount of lipoid phosphorus per unit of fat decreases. The amount of nitrogen per unit of fat decreases practically uniformly as the fat concentration increases from 17 per cent to 81 per cent. The point of the sharp break in the lipoid phosphorus curve at 60–65 per cent fat concentration has been suggested by Perlman (14) as the point of phase reversal in the emulsion system. No evidence of phase reversal is detectable microscopically. It seems to the authors that this point of the sharp break (Figure 1) is the point at which some of the tightly held phospholipid material in the fat globule membrane must be removed if one is to secure a cream with a higher fat content than 60–65 per cent. Below this fat concentration separation results only in removing part of the free skim milk portion of the milk, but it appears to be necessary to remove some of the membrane material to secure cream of greater fat content.

Table 1 shows that whatever materials are removed from the surface of

the fat globules by separation may be readsorbed. It is apparent that this may take place when the entire membrane is not removed since some of the membrane remains on the surface of the globules even in 80 per cent cream.

The washed cream studies reveal certain facts as shown in Figure 2. Most of the protein of the milk plasma is removed by the first washing. The removal of phospholipids and of protein after the first washing is a gradual process through eight washings and there is no apparent place where there is any change in the ease of removal of either. There was considerable "oiling off" after eight washings.

The synthetic milk studies indicate that it is possible to reconstruct milk exhibiting properties of normal milk. The position of the isoelectric points of the fat globules in the different systems studied suggests, when considered in conjunction with other data presented, that the membrane on the surface of the fat globules is a phospholipid-protein complex, in which the phospholipid is oriented toward the fat and the protein into the liquid phase. This arrangement is also in accord with current views in regard to molecular polarity and molecular orientation as presented by Harkins (16) and Langmuir (17).

The authors wish to call attention to the fact that casein was used in the adsorption studies solely because it was the only milk protein available in usable form and not because of any views they might have had regarding the nature of the protein normally present. They have presented no data concerning the protein that might be present in the membrane of normal milk.

SUMMARY AND CONCLUSIONS

The lipoid phosphorus content per unit of fat declines slightly in creams from 17 per cent fat to 60–65 per cent fat and above 65 per cent fat it decreases rapidly up to a fat content of 81 per cent.

The electrophoretic mobilities of the fat globules is constant up to a fat content of 65 per cent and above this they increase rapidly.

The nitrogen content decreases gradually with increasing fat content.

In washed cream most of the protein was lost in the first washing and there was a gradual decrease in protein content thereafter up to eight washings. The phospholipid content decreased gradually throughout the washings.

Synthetic milk, in which a casein layer is adsorbed on a phospolipid layer existing on the surface of fat globules, resembled normal milk in the position of the isoelectric point and the slope of the pH/mobility curve, suggesting the probability of a double layer membrane on the surface of the fat globules.

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POWER REQUIREMENTS FOR FREEZING ICE CREAM[1]

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INTRODUCTION

Some difficulty has been experienced in attempting to freeze and whip heavy, viscous ice cream mixes in a forty quart, direct expansion freezer, equipped with a 3 H.P. motor. Excessive heating of the motor, reduced dasher speed, and blown out fuses were frequently encountered, especially when an attempt was made to draw ice cream from the freezer at 24° F. or below.

In an effort to find a remedy for these difficulties, a larger motor was used on the freezer and the speed of the freezer dasher increased by means of a larger pulley. Other factors included studies relative to the effect of shutting off the refrigerant at various temperatures, varying the percentage and kind of stabilizer, and the use of egg yolk in the mixes upon the power requirements for the freezer and the quality of the ice cream.

REVIEW OF LITERATURE

Previous work dealing with power requirements for ice cream freezers has been confined largely to commercial plants, some of which were using methods no longer applicable to present day plant practices. It was reported by Turnbow (1) that the average power load for a forty quart freezer was 2.12 H.P. and the energy consumed per batch varied from 0.279 to 0.522 kilowatt hours. The variation in the power load throughout the freezing process, as reported by Reid (2), increased from 0.60 H.P. at the end of the first minute of freezing to 4.33 H.P. at the time the ice cream was drawn from the freezer. More recent data collected by DePew (3) indicate that the maximum power load was reached at the time the refrigrant was cut off, after which it declined. The amount of power required to manufacture a gallon of ice cream was calculated by Vetter (4) to be 0.319 kilowatt hours, about one-fifth of which was consumed by the freezer.

The need for more powerful motors and a higher dasher speed when freezing ice cream to below 24° F. was suggested by Olson (5) and Thomas (6). These investigators found that the use of low temperature refrigerants resulted in excessive vibration of the freezer. The vibration was attributed to inadequate speed of the scraping blades which allowed the mix to freeze in thick layers on the wall of the freezer. By increasing the dasher

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speed from 169 to 220 revolutions per minute, Thomas (6) was able to overcome excessive vibrations, but the increased speed caused the motor to heat, indicating the need of a larger motor. Overheating was eliminated by replacing the 7.5 H.P. motor with a 10 H.P. variable speed motor. A reduction in dasher speed from 230 to 100 revolutions per minute after the refrigerant was shut off did not affect the rate of whipping and made it possible to eliminate the difficulty previously encountered in controlling overrun during the drawing period.

Reichert (7) found that increasing the speed of the scraping blades was more effective than increasing the speed of the beaters, in speeding up freezing and improving the quality of the ice cream. Other than the work of Olson, Thomas, and Reichert, most of the power studies on ice cream freezers have dealt with operating costs. Little attention has been given to the efficiency of the freezing process and its relation to improvement in the quality of ice cream.

EXPERIMENTAL PROCEDURE

This experiment may be divided into five parts. In Part I the refrigerant was cut off at 25.5° F., 24° F., and 22.5° F. Observations were made on the final temperature of the ice cream when drawn from the freezer, the time required to obtain 100 per cent overrun, the body and texture score of the ice cream, the dasher speed, the energy input to the motor, and the total power required for freezing. A forty quart, direct expansion freezer (Creamery Package) was used for freezing a standard 12 per cent fat ice cream mix. A kilowatt hour-meter was used to measure the total power consumed. A continuous record of the energy input to the motor was obtained by the use of a recording watt meter. At one minute intervals during the freezing process, the temperature of the mix and speed of the dasher were recorded; and at two minute intervals, overrun determinations were made. The temperature of the mix was obtained with a suitable thermometer graduated to 0.1 ° F. inserted through the peep hole of the freezer to a uniform depth in the mix. The dasher speed was read from a millivoltmeter actuated by an electric tachometer belted to the dasher shaft of the freezer. Overrun percentages were determind wtih a Mojonnier overrun tester. The quality of the finished ice cream was measured by scoring properly hardened pint samples which had been taken from the freezer when the overrun reached 85 per cent.

In Part II the procedure was the same except that the 22.5° F. temperature for cutting off the refrigerant was eliminated because in Part I it proved to be impracticable. In this trial, mixes containing no stabilizer were compared with those containing 0.25 and 0.35 per cent of a 250 Bloom strength gelatin and those containing 0.26 per cent of Dariloid.

In Part III the results obtained when operating the freezer with a 3 H.P.

motor were compared with those obtained with the same freezer powered by a 5 H.P. motor. The standard mix of Part I was used.

Part IV was similar to Part III except that 1.5 per cent egg yolk was added to the standard mix, and the dasher speed increased from 170 to 200 revolutions per minute.

Part V consisted of a comparison of different dasher speeds using a 5 H.P. motor to freeze both a standard mix and a mix containing 1.5 per cent egg yolk.

DISCUSSION OF RESULTS

Part I—Effect of Cutting Off the Refrigerant at Various Temperatures

Lowering the temperature at which the refrigerant was cut off reduced the dasher speed and the rate of whipping while it increased the energy input to the motor and the total power used in freezing. (Table 1 and Fig. 1.)

TABLE 1

Relation of temperature at which the refrigerant was cut off to the rate of freezing, the quality of the finished ice cream, and total power consumed

(3 H.P. motor, initial dasher speed approximately 170 R.P.M.)

TRIAL	NO. OF BATCHES	MIX USED	TEMPERATURE AT WHICH REFRIGERANT WAS SHUT OFF	DRAWING TEMPERATURE	TIME REQUIRED TO OBTAIN 100% OVERRUN	BODY AND TEXTURE SCORE OF FINISHED ICE CREAM	TOTAL POWER USED
			(°F.)	(°F.)	(Min.)		(K.W.H.)
A	3	Standard*	25.5	24.1	11.2	23.6	0.26
B	3	"	24.0	23.0	15.4	23.8	0.46
C	3	"	22.5	22.4	20.3	24.1	0.69

* (12 per cent fat, 10 per cent serum solids, 15 per cent sugar and 0.35 per cent gelatin.)

No significant differences were observed in the quality of the ice cream when the refrigerant was cut off at 24° F. as compared with 25.5° F. A definite improvement in quality, however, resulted by cutting off the refrigerant at 22.5° F., but the use of such a low temperature with this particular equipment was not practicable nor economical due to the increased power consumption and prolonged freezing time. In all subsequent trials the temperature 22.5° F. was eliminated.

Part II—Effect of Varying the Kind and Amount of Stabilizer

The primary objectives of the second part of this study were first, to determine if the stabilizer in the mix could be reduced or eliminated by lowering the drawing temperature; and second, to compare the freezing

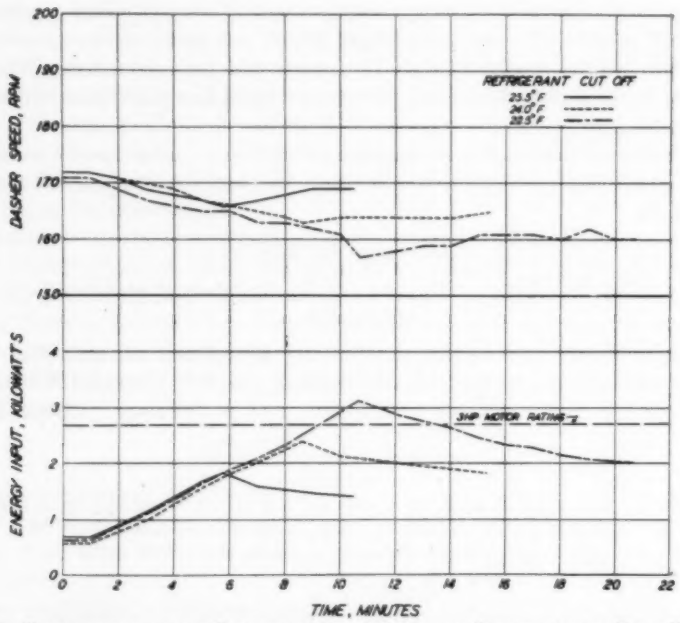

FIG. 1 RELATIONSHIP OF THE TEMPERATURE AT WHICH THE REFRIGERANT IS SHUT OFF TO DASHER SPEED AND ENERGY INPUT TO THE MOTOR. (STANDARD MIX 3 H.P. MOTOR.)

properties of mixes stabilized with gelatin and Dariloid, when the refrigerant was cut off at two different temperatures. Although the influence of stabilizers on the energy input and total power consumed was determined, this was of secondary importance.

The use of a stabilizing agent in the mix had a more significant effect on the quality of the ice cream than did a reduction in the drawing temperature within the limits observed (22.7–23.8° F., Table 2). Although absence of stabilizer in the mix, or the use of a limited amount, slightly reduced the time and total power required to freeze, such practices can not be recommended because of their adverse effect on the quality of the ice cream.

Reduction in the drawing temperature, within the limits previously mentioned, had no significant influence on quality. In two of the trials (Trials C and D, Table 2) the ice cream drawn at the higher temperature scored slightly higher than that drawn at the lower temperature. These results emphasize the fact that many factors other than drawing temperature may influence the quality of ice cream.

As the temperature at which the refrigerant was cut off was lowered the time required to obtain 100 per cent overrun and the total power were increased (Table 2). These results are in harmony with those obtained in

TABLE 2

Relation of the kind and percentage of stabilizer used to the rate of freezing, the quality of the finished ice cream, and total power used when the refrigerant was cut off at 25.5 and 24 deg. F. respectively

(3 H.P. motor initial dasher speed approximately 170 R.P.M.)

TRIAL	NO. OF BATCHES	MIX USED*	TEMPERATURE AT WHICH REFRIGERANT WAS SHUT OFF	DRAWING TEMPERATURE	TIME REQUIRED TO OBTAIN 100% OVERRUN	BODY AND TEXTURE SCORE OF FINISHED ICE CREAM	TOTAL POWER USED
			(°F.)	(°F.)	(Min.)		(K.W.H.)
A	3	No stabilizer	25.5	23.6	9.8	22.3	0.29
A_1	3	No stabilizer	24.0	22.8	12.7	22.3	0.55
B	2	0.25 per cent gel.	25.5	23.7	10.5	22.6	0.29
B_1	2	0.25 per cent gel.	24.0	22.7	13.5	22.6	0.50
C	3	0.35 per cent gel.	25.5	23.8	11.7	23.6	0.36
C_1	3	0.35 per cent gel.	24.0	23.2	15.8	23.3	0.63
D	3	0.26 per cent Dariloid	25.5	23.8	10.7	23.5	0.35
D_1	3	0.26 per cent Dariloid	24.0	23.1	15.0	23.3	0.60

* All mixed reported in this table had the same composition as the standard mix except for the stabilizer.

Part I. The increase in freezing time resulting from cutting off the refrigerant at 24° F. instead of 25.5° F. varied from 2.9 minutes per batch when no stabilizer was used to slightly over 4 minutes when standard amounts of either gelatin or Dariloid were used. It would appear that the time required to freeze is most adversely affected by the use of a lower drawing temperature when stabilizers are used in the mix.

When the refrigerant was cut off at 24° F. the total power used was from 71 to 90 per cent more than when the refrigerant was cut off at 25.5° F. The largest percentage increase in total power used occurred with the mix containing no stabilizer, and the smallest increase occurred with the mix stabilized with Dariloid.

The total power required to freeze comparable mixes was considerably higher in Part II than it was in Part I (C and C_1, Table 2 and Table 1). This difference amounted to 0.10 kilowatt hours when the refrigerant was cut off at 25.5° F. and 0.17 kilowatt hours when the refrigerant was cut off at 24° F. No satisfactory explanation has been found for these differences. The slight increase in time required to obtain 100 per cent overrun in Part II would be a contributing factor to the increase in total power but it probably does not account for all the difference. These data substantiate the results reported by Turnbow (1) in showing that the power requirements

may vary rather widely even with the same freezer operated under as nearly uniform conditions as possible.

Parts III and IV—Comparison of 3 and 5 H.P. Motors

Replacing the 3 H.P. motor with a 5 H.P. motor slightly reduced the time required to obtain 100 per cent overrun, and the total power used, when freezing a standard mix (Table 3). The ice cream was either equal

TABLE 3

Relationship of motor size to the rate of freezing, the quality of the finished ice cream and total power consumed

(Initial dasher speed approximately 170 R.P.M. in all trials)

TRIAL	NO. OF BATCHES	MIX USED	MOTOR SIZE	TEMPERATURE AT WHICH REFRIGERANT WAS SHUT OFF	DRAWING TEMPERATURE	TIME REQUIRED TO OBTAIN 100% OVERRUN	BODY AND TEXTURE SCORE OF FINISHED ICE CREAM	TOTAL POWER USED
			(*H.P.*)	(°*F.*)	(°*F.*)	(*Min.*)		(*K.W.H.*)
A	4	Standard*	3	25.5	23.8	11.7	23.6	0.36
B	3	"	5	25.5	24.0	11.4	23.5	0.33
C	4	"	3	24.0	23.2	15.7	23.6	0.65
D	3	"	5	24.0	23.1	15.1	24.0	0.60

* (12 per cent fat, 10 per cent serum solids, 15 per cent sugar, and 0.35 per cent gelatin).

to or superior in quality to that obtained when the 3 H.P. motor was employed.

In freezing a mix containing egg yolk, the 5 H.P. motor again proved superior. The freezing time and the total power were slightly reduced and the quality of the ice cream improved (Table 4).

TABLE 4

Relationship of motor size to the rate of freezing, the quality of the finished ice cream and total power consumed. Mixes contained 1.5 per cent frozen egg yolk

(Initial dasher speed approximately 200 R.P.M.)

TRIAL	NO. OF BATCHES	MIX USED	MOTOR SIZE	TEMPERATURE AT WHICH REFRIGERANT WAS SHUT OFF	DRAWING TEMPERATURE	TIME REQUIRED TO OBTAIN 100% OVERRUN	BODY AND TEXTURE SCORE OF FINISHED ICE CREAM	TOTAL POWER USED
			(*H.P.*)	(°*F.*)	(°*F.*)	(*Min.*)		(*K.W.H.*)
A	1	Egg mix*	3	25.5	24.1	9.3	23.8	0.38
B	3	" "	5	25.5	24.0	8.9	24.1	0.37
C	2	" "	3	24.0	22.7	10.6	23.6	0.58
D	3	" "	5	24.0	22.9	10.0	24.1	0.48

* Egg mix contained 1.5 per cent frozen egg yolk in addition to the constituents contained in the standard mix.

The differences observed in the quality of the ice cream as affected by

the size of motor were small, the maximum difference amounting to only 0.5 of a point in body and texture score. Although such small differences are of doubtful significance, at least the conclusion seems warranted that the use of a larger motor on the freezer will not adversely affect the quality of the ice cream.

It has been assumed that the use of a 5 H.P. motor would be effective in preventing a drop in dasher speed but the data only partially substantiate this assumption. (See Figs. 2 and 3.) There was little difference in the

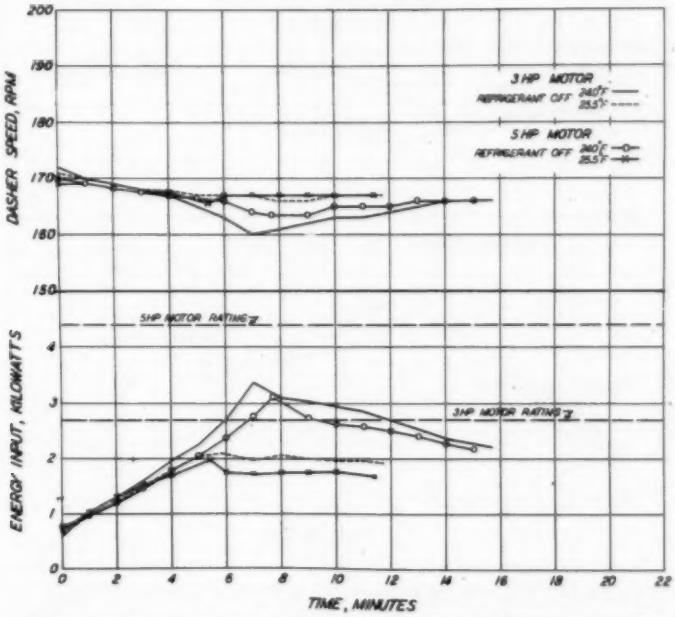

FIG. 2. EFFECT OF MOTOR SIZE ON THE ENERGY INPUT TO THE MOTOR AND DASHER SPEED. (STANDARD MIX USED IN ALL TRIALS.)

dasher speeds with either motor when the refrigerant was cut off at 25.5° F. At the lower drawing temperature, however, the drop in dasher speed was not as pronounced with the 5 H.P. motor as it was with the smaller motor (Figs. 2 and 3).

The energy input to the two motors was very similar in all cases when comparable conditions prevailed (Figs. 2 and 3). The peak load in every case, however, was higher for the 3 H.P. than for the 5 H.P. motor. The maximum energy input for the standard mix was not as great as it was for the mix containing egg yolk. When the 3 H.P. motor was used and the refrigerant was shut off at 24° F., the maximum energy input to the motor amounted to 3.37 kilowatt hours with the standard mix as compared with

4.55 kilowatt hours with the egg mix. The latter figure represents a load in excess of the rating of the 5 H.P. motor. Similar differences were observed with the 5 H.P. motor. In no case, however, was the 5 H.P. motor overloaded. The need for a motor of ample power capacity when egg mixes are frozen is clearly indicated.

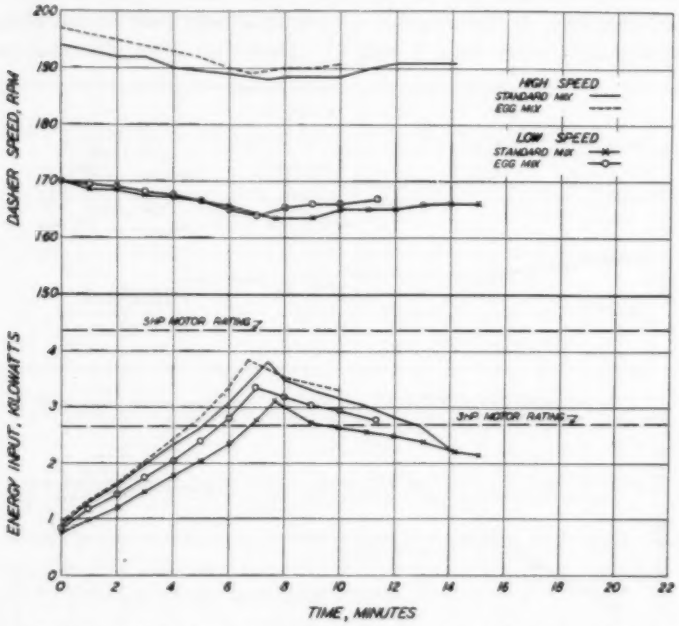

FIG. 3. EFFECT OF MOTOR SIZE ON THE ENERGY INPUT TO THE MOTOR AND DASHER SPEED WHEN AN EGG MIX WAS FROZEN AND THE REFRIGERANT SHUT OFF AT 24° F.

In the case of the mixes containing egg yolk the time required to obtain 100 per cent overrun was greatly shortened. The saving in time effected by the addition of eggs was most significant when the refrigerant was shut off at 24° F. A saving in time of 2.5 minutes per batch in favor of the mixes containing egg yolk irrespective of the motor used resulted when the cut off temperature was 25.5° F. When the refrigerant was cut off at 24° F., the saving in time effected by the use of egg yolk averaged 5.1 minutes per batch. (Tables 3 and 4.)

Although it was possible through the use of egg yolk in the mix to draw the ice cream from the freezer at a lower temperature and still obtain the desired overrun within a reasonable period of time, no beneficial effects from this procedure resulted as far as the quality of the finished ice cream was concerned.

Part V—Effect of Dasher Speed

Two different dasher speeds—170 R.P.M. in Part III and 200 R.P.M. in Part IV—were used in the comparisons made between the standard mix and the egg mix. This raised the question as to just how much influence a change in dasher speed would have on the rate of freezing, the quality of the finished ice cream, and the total power required.

TABLE 5

Relationship of dasher speed to the rate of freezing, the quality of the finished ice cream and total power consumed

(5 H.P. motor)

TRIAL	NO. OF BATCHES	MIX USED	DASHER SPEED	TEMPERATURE AT WHICH REFRIGERANT WAS SHUT OFF	DRAWING TEMPERATURE	TIME REQUIRED TO OBTAIN 100% OVERRUN	BODY AND TEXTURE SCORE OF FINISHED ICE CREAM	TOTAL POWER USED
				(°F.)	(°F.)	(Min.)		(K.W. H.)
A	3	Standard	low	24.0	23.1	15.1	24.0	0.60
B	3	Standard	high	24.0	23.2	14.1	24.2	0.65
C	3	Egg	low	24.0	22.7	11.4	24.3	0.50
D	3	Egg	high	24.0	22.9	10.0	24.1	0.48

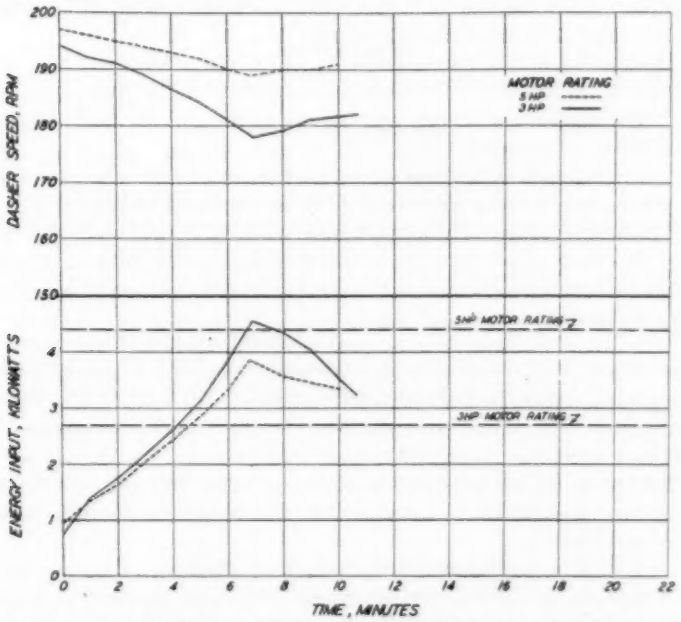

FIG. 4. RELATIONSHIP OF DASHER SPEED TO THE ENERGY INPUT TO THE MOTOR. (5 H.P. MOTOR. INITIAL DASHER SPEEDS APPROXIMATELY 170 AND 200 R.P.M.)

An increase in the speed of the dasher reduced the time required to obtain 100 per cent overrun and slightly increased the energy input to the motor but did not appreciably effect the total power required to freeze (Table 5 and Fig. 4).

The maximum drop in dasher speed amounted to 6.5 R.P.M. with the standard mix, irrespective of the initial speed. In the case of the mix containing egg yolk the drop in dasher speed amounted to 8 R.P.M. at the higher speed (200 R.P.M.) and 6 R.P.M. at the lower speed (170 R.P.M.). These data would seem to indicate that the decrease in dasher speed is fairly uniform irrespective of the initial speed of dasher.

No effect on the quality of the ice cream was observed as a result of changing the speed of the dasher.

SUMMARY AND CONCLUSIONS

In an attempt to improve the operating efficiency of the 40 quart, direct expansion freezer (Creamery Package) a total of 66 individual batches of ice cream have been made. The rate of freezing, the quality of the finished ice cream, and energy input to the motor were determined in relation to the temperature at which the refrigerant was cut off, the percentage and kind of stabilizer used, the size of motor, and the dasher speed. The results of this study may be summarized as follows:

1. Reduction in the temperature at which the refrigerant was cut off from 25.5 to 24 and 22.5° F. resulted in a decline in the dasher speed and rate of freezing but the energy input to the motor and the total power used in freezing were increased.

2. No significant differences were observed in the quality of ice cream when the refrigerant was cut off at 24° F. as compared with 25.5° F.

3. Although cutting off the refrigerant at 22.5° F. improved the quality of the ice cream, this temperature was neither practicable nor economical with the equipment used, due to prolonged freezing time and the increased power consumption.

4. The use of the proper amount of a suitable stabilizer had a more significant effect on the quality of the ice cream than did a reduction in the drawing temperature within the limits observed (22.7–23.8° F., Table 2). No significant differences were observed in the freezing properties, total power used, or in the quality of the ice cream stabilized with 0.35 per cent of a 250 Bloom strength gelatin as compared with 0.26 per cent Dariloid. The addition of stabilizer to a standard mix increased the freezing time and total power slightly.

5. A 5 H.P. motor improved the operating efficiency of the freezer and did not increase the total power consumed. The time required to reach 100 per cent overrun was slightly reduced and the quality of the ice cream was either equal to or superior to that produced with the 3 H.P. motor. In no

case was the 5 H.P. motor overloaded, whereas the 3 H.P. motor was seriously overloaded, particularly when a mix containing egg yolk was frozen and the refrigerant cut off at 24° F.

6. A marked difference in the energy input to the motor was observed between mixes containing egg yolk and the standard mix, irrespective of the size of motor used. When the 3 H.P. motor was used and the refrigerant was cut off at 24° F. the maximum energy input to the motor amounted to 3.37 kilowatt hours with the standard mix as compared with 4.55 kilowatt hours with the mix containing egg yolk. Similar differences were observed when the 5 H.P. motor was used.

7. The use of eggs in the mix shortened the time required to reach 100 per cent overrun. A saving of approximately 5.1 minutes per batch resulted when the refrigerant was cut off at 24° F., and a saving of 2.5 miuutes per batch when the cut off temperature was 25.5° F.

8. Increasing the dasher speed from approximately 170 R.P.M. to 200 R.P.M. resulted in a slight saving in the time required to reach 100 per cent overrun. The energy input to the motor was increased but the total power was not affected appreciably.

9. Changing the speed of the dasher had no significant effect on the quality of the ice cream.

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A STUDY OF SOME FACTORS IN THE BUTTER CHURNING PROCESS

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The two most widely accepted explanations of the mechanisms of butter churning are those of Fischer and Hooker, usually referred to as the phase reversal theory (2), and the theory of Rahn (4), known as the foam substance theory. It is the opinion of some (7) that "the difference in the two theories lies mainly in the matter of point of view and of definitions." Nevertheless the proponents of the Fischer and Hooker theory regard the change from cream to butter as essentially due to a more or less complete liberation of butter fat, whereas those who favor the Rahn theory regard the change as due chiefly to an irreversible coagulation of protein. The liberation of free butter fat is not an essential feature of the conversion of cream into butter, according to the Rahn theory.

In the course of an investigation of the nature of dairy foam systems, results were obtained which are not readily explained in terms of either of the two theories mentioned, and therefore, a study of some of the physico-chemical factors bearing on the churning process was undertaken.

It has been conceded by investigators who have studied the churning process, that the establishment of a foam precedes butter formation. The different theories of butter churning recognize that the agglomeration or coalescence of fat globules takes place in the foam.

In any particular cream the agglomeration of the fat globules in a foam, and their possible coalescence will be influenced chiefly by the following physico-chemical factors:

a. Thickness and nature of the film adsorbed on the globule. The liberation of free fat requires a rupture of the adsorbed film; agglomeration of the globules does not.

b. Viscosity of the interglobular liquid. Rapid drainage of liquid from the foam structure is favored by low viscosity of the solution between the foam walls.

c. Electric charge on the globules. Lowering of the electric charges will diminish the repulsion of similarly charged fat globules, and will favor their coalescence.

It is evident that the physical properties of the fat-free portion of the film, forming the foam walls are important. A relatively strong film, which

[1] This paper is based on a thesis submitted by David Levowitz to the Faculty of the graduate school of Rutgers University, in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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resists distortion and destruction of the foam walls, will tend to retard globule agglomeration and coalescence.

EXPERIMENTAL

The Thickness of Casein Films Adsorbed on Oil Globules

The stability of the fat globule in milk is chiefly due to an adsorbed protective film, the precise nature of which is still in doubt. Most investigators regard it as made up of casein and other proteins, together with phospholipids. King (3) supposes that the crystallization of fatty constituents with high melting-point may be a factor in producing a stable globule. Wiegner (8) has calculated that in normal milk approximately two per cent of the protein is adsorbed on the globules. This calculation is based on the assumption that the thickness of the stabilizing film is in the neighborhood of 6 m μ.

The complex nature of butter fat and of the aqueous solution of milk make it extremely difficult to determine experimentally the amount of substance in the adsorbed film. It seemed worth while to attempt an experimental verification of Wiegner's calculation in the case of a simplified system, consisting of a dispersion of a mineral oil in a solution of casein in water. Such a mineral oil contains no polar groups and cannot be considered strictly analogous to butter oil. Since an oil containing polar groups will presumably have a greater attraction for casein than a mineral oil, we may conclude that if we get adsorption with the latter, we should also find it with the former. The method used was similar in principle to that used by Rieman and van der Meulen (6).

The forces which give rise to adsorption are effective over short distances, and after the first layer of adsorbed material is formed on the oil globule, adsorption may be regarded as taking place on a surface of adsorbed emulsifying agent. There is, however, the possibility that some of the fat or oil will become a part of a complex protective film, and the methods of analysis used would not make possible a distinction between oil in the globule and oil in the interfacial film.

A hydrocarbon oil (Nujol) was emulsified in a solution of casein in water by the use of a colloid mill. The emulsions were allowed to "cream" and the concentration of casein in the total emulsion, and in the aqueous portion was determined.

The surface area of the oil globules was obtained by measuring the diameters and the numbers of oil globules in photomicrographs of several emulsions. It was found that one cubic centimeter of oil, when emulsified under the conditions described, possessed an average surface area of 6220 square centimeters. While there was some variation from this average, the result is sufficiently accurate for the purpose in mind.

The density of casein was assumed to be 1.28. In seven experiments the thickness of the adsorbed layer was found to be 4.4, 4.2, 2.2, 1.4, 2.1, 1.4, and

3.0×10^{-7} cm. The concentration of casein in the aqueous phase varied from 0.45 to 4.5 per cent by weight. The observed thickness does not seem to bear any simple relation to the concentration of casein in the aqueous phase. This is probably due to the fact that the experimental method is not sufficiently accurate to give the small differences in quantity of casein at the interface in the different solutions. The results obtained, however, are definitely of the same order of magnitude as those calculated by Wiegner (10).

Churning Trials with Modified Creams

In these experiments we attempted to reduce the variables involved in the churning process by removing as much as possible of the normal serum solids and salts of the cream, and replacing these with other materials. The procedure used was to separate fresh morning milk, obtained from the College Farm herd, by means of a centifugal separator to produce a cream of approximately 40 percent fat content. The cream was diluted with ten volumes of distilled water and reseparated. This dilution and separation process was repeated twice. The cream obtained after three washings, and standardized to 40 percent butter fat, is referred to as "washed" cream. Attempts to remove the serum solids more completely by washing resulted in partial oiling of the butter fat from the globules of the cream.

To different portions of this washed cream were added varying amounts of stabilizing substances. The first substance added was casein, resulting in what we shall call a "casein" cream, the second substance added was a reagent grade of lecithin, giving a "lecithin" cream, and in the third case, there was added a mixture composed of equal parts by weight of casein and lecithin, producing a "casein-lecithin" cream.

Forty gram portions of the washed cream were weighed into Mojonnier composite sample bottles and to each portion in turn were added 20 cc. of the proper solution to yield the desired concentrations of casein, lecithin, and casein-lecithin mixture respectively. The control consisted of washed cream diluted with distilled water.

The bottles were then rotated gently to mix their contents, and placed in a water bath at 7.0° C. These samples were churned at this temperature, although the range of normal churning temperatures is between 13.0° C., and 16.0° C. Earlier experiments had shown that the churning times of washed creams, with, and without added interglobular ingredients are increased as the churning temperature is lowered, and the differences in the churning times of different samples are thus observed more readily. Nevertheless, it should be borne in mind that the results described are for a specific temperature of 7.0° C.

Washed cream controls, prepared by mixing distilled water with no added interglobular ingredients, with washed cream, in the proper proportions, were included in each series of churning trials.

A shaking machine with provision for shaking 30 bottles at a time was placed in an atmosphere adjusted to 7.0° C. The filled bottles previously held at 7.0° C. were fastened in the carrier so that their distinguishing marks were always visible. The machine was started and was allowed to run until all the samples were churned. The churning time was taken to the nearest half minute. A sample was considered "churned" as soon as the walls of the bottle began to "wash clear."

The results of these churning trials were recalculated on the arbitrary basis of churning time of "washed" cream controls, taken as unity. These results are shown in Fig. 1.

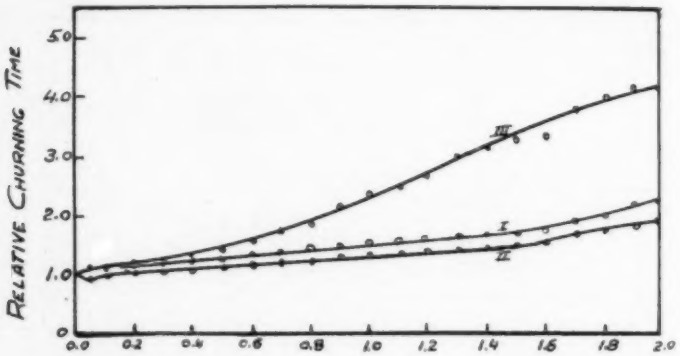


Fig. 1.

We have, here a series of results of churning creams which are considerably simpler than are creams ordinarily churned. Although the interglobular liquid is different from ordinary creams, the actual phenomena of churning, and the butter produced, show the same characteristics as those usually observed. These data, therefore, present an interesting opportunity for studying the effect of the electric charge carried by the globule, and of the viscosity of the interglobular liquid, on the rate of churning.

The Effect of the Electric Charge Carried by the Globules on Churning Time

Since the electric charge on the globule is determined by the substance adsorbed on the fat globules, any change in the interglobular liquid may bring about a change in this charge.

One cubic centimeter of washed cream was diluted to 250 cubic centimeters with interglobular solution, and this solution was used in the electrophoresis experiments. A portion of washed cream diluted with distilled

water served as a control, and the results are expressed on the basis of this control.

An all glass, flat electrophoresis cell, of the closed type was used, with copper electrodes in combination with a normal solution of copper sulfate. The rate of movement of globules was measured by timing the movement of the image of globules between fixed lines in the field, using a stop-watch. It was found that medium sized globules could be observed with greater accuracy than either large or small globules. The experiments were carried out at 30° C., and rate measurements were made of globules at three levels of the cell, namely at the middle, at one third, and at one sixth of the depth of the cell.

The following formula (1) gives the rate of movement of globules in an electric field.

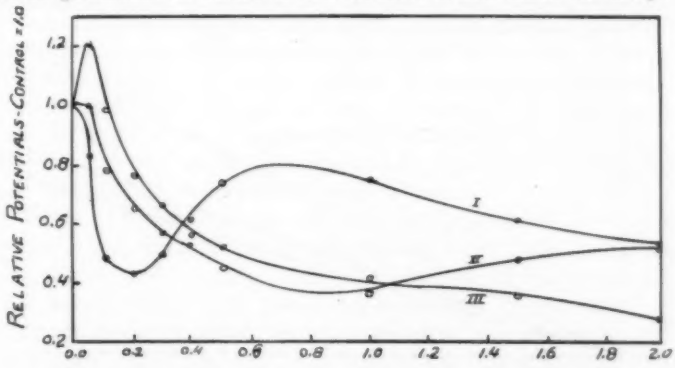
$$V = \frac{\zeta D X}{4\pi \eta}$$

where ζ = electrokinetic potential
D = dielectric constant
X = potential gradient
η = viscosity of the medium

For a constant potential difference, a constant dielectric constant, and in the same apparatus, we have

$$\frac{\zeta_1}{\zeta_2} = \frac{V_1 \eta_1}{V_2 \eta_2}$$

If we take ζ_2, the electrokinetic potential of washed cream as an arbitrary standard, we can express the charge on the fat globules as the relative electrokinetic potentials in terms of the washed cream taken as unity. The



RELATIVE ELECTROKINETIC POTENTIALS OF GLOBULES

FIG. 2.

viscosities of the interglobular liquids was taken, at 30° C., with an Ostwald viscosimeter. The electrokinetic potentials determined at the three levels were averaged for each series of measurements, and are given in Table 1, and are shown graphically in Fig. 2.

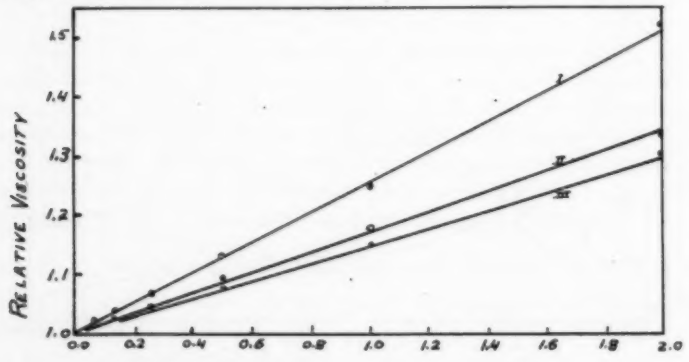
TABLE 1

Average relative electrokinetic potentials on butterfat globules in solution of casein, lecithin, and casein-lecithin mixtures

CONCENTRATION OF SUBSTANCES DISSOLVED IN WATER	CASEIN	LECITHIN	CASEIN AND LECITHIN
percent			
0.05	0.83	1.21	0.99
0.10	0.48	0.98	0.78
0.20	0.43	0.76	0.76
0.30	0.50	0.66	0.57
0.40	0.61	0.55	0.53
0.50	0.74	0.52	0.45
1.00	0.74	0.42	0.37
1.50	0.61	0.35	0.48
2.00	0.53	0.28	0.53

NOTE: Figures are averages of relative values based on washed cream diluted with distilled water, taken as 1.00.

A comparison of the results shown in Fig. 2, with those represented in Fig. 1, which gives relative churning times, shows that the electric charge on the butter fat globule has either no effect, or a very minor one, on the churning process. One would expect that reduction of the like charges on the globules would increase the ease of their agglomeration; the results of the electrophoresis trials indicate that this property is of minor importance.



CONCENTRATION OF SOLUTE - PERCENT

I - CASEIN II - CASEIN - LECITHIN III - LECITHIN

RELATIVE VISCOSITIES OF SOLUTIONS AT 7°C.

FIG. 3.

The Effect of the Viscosity of the Interglobular Liquid on Churning Time.

Interglobular solutions were prepared of casein, lecithin, and casein-lecithin, and the viscosities were determined as 7° C., the churning temperature. The determinations were carried out by means of the Ostwald pipette, and the results are expressed as relative viscosities based on the viscosity of distilled water, at 7° taken as unity. The results are given in Table 2 and in Fig. 3.

It will be noted that the relative viscosity is a linear function of the concentration in all three cases. The viscosity of the casein solution is greatest, that of the lecithin smallest, and that of the casein-lecithin is intermediate, but nearer that of lecithin.

TABLE 2

PERCENT SOLUTE	RELATIVE VISCOSITY (WATER AT 7° C. = 1)		
	Casein solution	Lecithin solution	Casein-lecithin solution
0.0625	1.025	1.012	1.010
0.125	1.038	1.018	1.022
0.25	1.065	1.039	1.046
0.50	1.133	1.074	1.098
1.0	1.255	1.152	1.183
2.0	1.529	1.309	1.337

A comparison of the results for churning times and viscosities shows that the casein modified creams have a much higher viscosity than the lecithin modified creams, but that the casein creams churn more quickly.

DISCUSSION OF RESULTS

The fact that a reduction of the electric charge on the globules does not hasten churning may be interpreted in at least two ways. It may be that the residual charges, even on the globules which carry the smallest charges, are still so large that the globules have little if any increased tendency to coalesce, or that the kind of agglomeration which takes place is not governed at all by the charge on the particles, but is a phenomenon dependent on a change involving an electrically neutral substance.

The rate of drainage of the interglobular liquid from the foam must be inversely proportional to the viscosity of the liquid. It is surprising that the increase in viscosity has so little effect on the rate of churning. It may be that actual clumping of the globules does not depend on complete or nearly complete drainage of the liquid from the foam structure.

It appears that the specific properties of the film surrounding the globules are of the greatest importance in the churning process. A similar conclusion is reached by Rahn (5), but our results indicate that Rahn places too much emphasis on the importance of his hypothetical "foam substance." Washed cream churns much more easily than normal cream. If churning

depends on the irreversible coagulation of "foam substance" it is difficult to explain this result. Furthermore, the introduction of casein and lecithin, in relatively large quantity into the cream, replacing the normal interglobular solutes does not seem to alter the essential features of the churning process.

Our results can be explained satisfactorily by assuming, as Rahn does that the first step in the churning process leads to the production of a foam, containing a high concentration of fat globules, and that in the second step a large proportion of the milk serum drains from the foam. Rahn assumes that the next step is the irreversible coagulation of the "foam substance," resulting in the formation of a rigid structure containing globules of butter fat still stabilized by their original protein films. Instead of assuming that this irreversible coagulation of a hypothetical foam substance is the next step, we assume that, as a result of the mechanical action of the churn, the stabilizing films of some of the fat globules are broken, liberating the oil from the least stable globules, but leaving the more stable globules essentially unchanged. The free oil produced by the rupture of the least stable globules forms a cementing material for the stable globules in its immediate vicinity.

The stage in which this rupture and initial cementing takes place is the stage ordinarily recognized as the "breaking point." Such a spreading and cementing would take place equally well on a globule with a large charge as on one with a small charge, and would not be governed by the viscosity of the interglobular liquid. It would, therefore, explain the apparently negligible effect which electrical charge on the globules, and viscosity of the medium have, on the churning time.

The Production of Butter without Churning

If the view which we have expressed is correct, that the conversion of cream into butter does not depend on "foam substance" coagulation, but rather on the production of a certain proportion of unstable globules, it should be possible to produce butter without churning. All that is necessary is to bring about a condition in which a part of the globules are caused to set free their fat, in the presence of stabilized globules.

The stability of the globules in a cream is lowered by decreasing the concentration of serum solids, and by raising the temperature. Therefore, by proper dilution and elevation of the temperature, followed by centrifuging, we should obtain butter directly from a cream separator.

In a particular experiment, forty percent cream was diluted with ten volumes of water, and warmed to 125–130° F. It was then passed through a centrifuge, which had been adjusted to reduce the rate of flow by constricting the orifice of the milk reservoir, and to increase the concentration of butter fat in the cream by turning the cream screw. The cream outlet of the separator was warmed to keep the fat in a liquid state. Under these

conditions the product which issues from the separator is butter, that is, it is not redispersed by stirring with water, and was identified as butter by several individuals, skilled in the art of butter-making. Its consistency can be controlled within wide limits by regulating the dilution and temperature of the cream. In this process we do not have the possibility of denaturation of the "foam substance," and yet the product is the same as that produced in the classical churning method.

ACKNOWLEDGEMENT

We wish to express our appreciation to Professor F. C. Button of the Dairy Department of Rutgers University for his interest and for his advice in connection with certain parts of the work.

SUMMARY

1. A study of the distribution of casein between water and a mineral oil-water interface tends to confirm the conclusion of Wiegner with respect to the thickness of the interfacial film.

2. Results are described, obtained in churning certain modified creams. The relative electrical potential on the butter-fat globules, and the viscosity of the interglobular solutions were determined. These two factors appear to have very little, if any, effect on churning time.

3. It is suggested that churning is due to the setting free of butter fat from the less stable globules, followed by a cementing of the more stable protected globules into clumps, by the free butter fat.

4. In support of this view, we have been able to produce butter, without churning under conditions that favor a decrease in stability of the fat globules.

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THE EFFECT OF TEMPERATURE AND TIME OF STORAGE OF CREAM ON THE RATE AND TYPE OF DETERIORATION[1]

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INTRODUCTION

The deterioration of cream from the time it is produced until it is finally made into butter has always been a problem of vital concern to the buttermaker. This problem is particularly important in those sections of the country served by the centralizer type of creamery, where the volume of cream produced per farm is often too small to expect daily deliveries. The cream is held on the farm for a period of time, sometimes a week or more, before it reaches the creamery. The conditions under which it is held, therefore, will have a direct bearing on the rate and amount of deterioration. The problem is accentuated during the seasons when high temperatures prevail. In the absence of adequate cooling facilities the cream will spoil very rapidly. If the spoilage is allowed to proceed until second grade cream results, the producer may be penalized; or if the cream should be condemned as unfit for butter-making purposes, he may suffer even a greater loss.

The factors responsible for the deterioration of cream are generally known. For many years cream producers have been advised to use sanitary methods of production, to cool cream and hold it at a temperature which will retard or prevent the growth of microbes which are agents of spoilage, and to market the cream frequently. There is, however, a lack of information on certain phases of the cream spoilage problem. The type of fermentation which takes place in cream, the extent to which it will proceed, and the by-products formed will depend upon the type of organisms present in the cream and upon time and temperature of holding. In the spoilage of cream the extent of microbial activity may be determined in various ways. The sense of taste and smell will detect off flavors and odors which may develop in the cream and make it possible to classify the cream into grades. The acidity determined by titration or by the pH method and the formol titration are tests which measure the amount of by-product of bacterial activity in the cream. Yeast and mold counts give some information regarding the care exercised in the production and handling of the cream.

It was the purpose of this experiment to study the relationship of temperature to the above factors.

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METHODS

In each trial a thoroughly mixed sample of No. 1 grade, sweet cream (35 per cent fat) was divided into nine equal portions and placed in separate incubators adjusted to operate at 50, 55, 60, 65, 70, 75, 80, 85, and 90° F., respectively. The various lots of cream were held at the indicated temperatures for 16 days or until they became third grade. In two of the trials (1A and 1B) the 55° F. and 85° F. temperatures were not used. The samples which were removed daily for use in grading and testing were labeled in accordance with a system of key numbers in order to conceal their identity and eliminate the inevitable personal factor when organoleptic methods are employed.

After each sample had been graded independently by three persons, an official grade was determined by mutual agreement or, if necessary, by reexamination of the sample.

The pH determinations were made by the quinhydrone method. The acidity calculated as lactic acid was determined by titrating duplicate 9 gram portions with 0.1 normal NaOH, using phenolphthalein as the indicator.

After neutralizing the samples to the end-point of phenolphthalein for the acidity test, 10 ml. of commercial formaldehyde (30–40 per cent HCHO), which previously had been neutralized to the end-point of phenolphthalein, was added to the cream and the mixture was again titrated to the end-point of phenolphthalein with 0.05 normal NaOH. This second titration known as the formol titration is expressed arbitrarily as the ml. of 0.05 normal NaOH required to neutralize the carboxyl groups freed as a result of the union of formaldehyde with the amino groups of proteins decomposed by biochemical processes.

In two of the trials yeast and mold counts were made on Difco dehydrated whey agar incubated five days at 70° F.

In one of the trials a sample of cream of poor sanitary quality was divided into two equal parts and 10 per cent of butter culture was added to one of the parts before subdividing each into nine smaller portions for incubation at the indicated temperatures. Since more than 5000 determinations were involved only typical data are presented.

The definitions given in the Kansas dairy law for cream grades were used as a basis for grading. First grade cream is defined as cream that is clean, smooth, free from undesirable odors, clean to the taste, and sweet or only slightly sour. Second grade cream is described as cream that is too sour to grade as first, that contains undesirable flavors and odors in a moderate degree, that is foamy, yeasty or slightly stale, or that is too old to pass as first grade. Third grade cream, or unlawful cream, consists of cream that is very old, rancid, moldy, dirty or curdy, which contains or has contained any foreign matter, or in which has been found unsanitary articles or utensils.

RESULTS

Changes Occurring During Storage

The holding of cream at various temperatures resulted in a change in the grade of the cream. Storage also affected certain chemical and bacteriological changes in the cream. Aside from the quality of the cream at the beginning of each trial the temperature and time of holding were largely responsible for the degree and extent to which these changes took place.

Grades. When cream was held at 50° F. it required from 11 to more than 16 days for it to become second grade. In contrast, at 90° F. only 1 to 4 days, with an average of 2 days, were required for a similar change in grade. The average time for change from first to second grade when the storage temperature was 70° F. or above was from 2 to 6 days (Table 1). In trials 2 to 6B (Table 2) the cream was purposely held until it became

TABLE 1

Days required for cream to change from first to second grade

TRIAL NO.	TEMPERATURE OF INCUBATION (°F.)								
	50	55	60	65	70	75	80	85	90
1–A	14	.....	9	7	7	5	4	.....	2
1–B	14	.....	8	10	10	4	3	.....	3
2	16*	9	9	9	3	2	2	2	2
3	11	8	7	3	4	3	2	2	2
4	16*	16*	16	15	8	8	6	4	4
5	15	15	15	12	8	6	5	3	4
6–A	14	9	10	9	7	6	3	3	2
6–B	16*	10	7	6	4	4	2	2	1
Average	15	11	10	9	6	5	3	3	2

* Still first grade cream 16th day but considered second grade in computing averages. No observation after 16th day.

third grade. It was found that cream held at 50° F. still graded second after 16 days of holding (Table 2). When the storage temperature was varied by 5° intervals between 50° F. and 90° F. the time required for cream to become third grade varied from 4 to more than 16 days.

Whenever it was possible to do so the judges noted the specific defects in flavor which were present. These defects were arranged in tabular form corresponding to the various trials and holding temperature. From this record it was possible to compile the figures presented in Table 3 showing the length of time required for various flavor defects to develop.

It required from 1 to 6 days for the cream to become sour. At the higher temperatures souring took place in a comparatively short time, and at the lower temperatures the best quality cream remained sweet for several days. Stale flavors were most prevalent in cream held for a considerable length of time at 75° F. or below, but in some instances this defect was not noted

TABLE 2

Days required for cream to change from first to third grade

NO. TRIAL	TEMPERATURE OF INCUBATION (°F.)								
	50	55	60	65	70	75	80	85	90
2	16*	11	12	16	10	9	6	6	5
3	16*	16	14	10	10	8	5	4	3
4	16*	16*	16*	16*	10	10	7	6	4
5	16*	16*	16*	15	10	10	7	4	4
6–A	16*	16	16*	14	10	7	4	6	4
6–B	16*	16*	12	6	4	6	4	6	4
Average	16*	15	13	13	9	8	6	5	4

* Still second grade cream on 16th day but considered third grade in computing averages. No observations after 16th day.

until from 7 to 14 days of storage (Table 3). Putrid flavors resulting from protein decomposition may take place at extremely high or extremely low temperatures. At intermediate temperatures 60 to 75° F. inclusive, the flavor was not found, indicating that different organisms may be responsible for the development of this flavor.

A flavor recognized as bitter was present quite frequently in the cream after 1 to 14 days of storage. The development of this defect was retarded by storage at low temperatures, although in some instances it appeared after 2 or more days of storage (Table 3). Another defect which showed up during the early stages of holding in many samples was designated by the term unclean. Rancidity was noticeable in the cream stored at 70° F. or above after 3 to 7 days. It appeared in 7 to 9 days in cream held at 60 and 65° F. At the two lowest temperatures rancidity did not develop, probably due to the inability of fat splitting enzymes to act.

TABLE 3

Minimum and maximum number of days required for specific defects to develop when and if they appeared in the cream held at various temperatures

(8 Trials)

FLAVORS	50 °F.	55 °F.	60 °F.	65 °F.	70 °F.	75 °F.	80 °F.	85 °F.	90 °F.
Sour	2–6	2	1–3	1–3	1–2	1–2	1–2	1	1–2
Stale	4–13	4–9	4–14	4–14	6–9	7	.....	2	.....
Putrid	9–20	14	.....	.....	.....	.....	4	.....	4
Bitter	2–10	4–14	2–9	1–10	2–8	1–10	1–4	2–7	1–4
Unclean	3–9	2–6	2–8	2–13	2–8	2–7	1–4	2	2–3
Musty	15	10–15	7	10	.....	6	.....	.....	.....
Rancid	.....	.....	8	7–9	4	7	4–7	3–7	4–5
Cheesy	.....	5	.....	3	3–11	4–11	2–6	3–5	1–3
Yeasty	.....	14	11–12	7–15	4–9	4–8	6–7	4–5	4–5

With one exception cheesy flavor was confined to cream stored at 65° F. or above, appearing quite early in cream held at 70° F. or above. Yeastiness, a common flavor defect of cream held at high temperatures, appeared in 4 to 5 days in cream held at 85 and 90° F. but as the holding temperature was reduced the appearance of the defect was retarded, 7 to 15 days being required for its presence at 65° F. At 50° F. no yeast flavor was noted. Certain flavor defects seem to appear at a rather fixed time when cream is held at any one of the various temperatures. If this is true, it should afford a possible index to the age of cream and the conditions under which it has been held.

Acidity. In many states the maximum titratable acidity* which will be tolerated in first and second grade cream is stipulated by law.

TABLE 4

The acidity of cream at the time it was classed as second and as third grade

TEMPERATURE OF HOLDING	PER CENT ACIDITY WHEN CREAM WAS CLASSED AS SECOND GRADE				PER CENT ACIDITY WHEN CREAM WAS CLASSED AS THIRD GRADE			
	Trial number				Trial number			
	4	5	6A	6B	4	5	6A	6B
50° F.	*	.49	.49	*	*	*		*
60° F.	*	.49	.60	.78	*	*		.78
70° F.	.72	.70	.79	1.05	.89	.93	1.26	1.05
80° F.	.83	.95	1.01	.80	.98	1.28	1.23	1.28
90° F.	1.03**	1.08**	.84	.94	1.03	1.08	1.62	1.83

* Not second grade after 16 days.

** Graded as third without a second grade period.

The data in Table 4 show the titratable acidities of each of four samples of cream held at 50, 60, 70, 80, and 90° F. when each was classed as second or as third grade cream. At the lower temperatures (50 and 60° F.) the cream was regarded as second grade at lower levels of acidity than the cream held at the higher temperatures. These data suggest that the establishment of a fixed value for the maximum acidity of cream of a given grade should take into consideration the possible effect of the temperature of storage on the type of changes which take place in the cream. Cream held at the lower temperatures was graded as second or third grade only after a prolonged period, during which time defects other than acidity had developed. In the higher ranges of temperature the rapid development of acidity not only resulted in an objectionable sharp, sour flavor but the changes in hydrogen-ion concentration apparently catalyzed other objectionable chemical or biochemical processes.

If cream is held at temperatures of 60° F. or below, an acidity in excess of approximately 0.6 per cent might be regarded as a fair index to second grade cream. Cream samples held at a temperature of 70° F., however, were

* The term acidity used throughout this article refers to titratable acidity.

not graded as second until acidities had reached 0.7 per cent or more, indicating that at the higher temperatures an acidity of approximately 0.8 might be a better index of grade. The rapidity of the biological and chemical changes in cream held at the higher temperatures may not have permitted accurate determination of the actual acidity at which the cream became second or third grade, especially when the interval between examinations was 24 hours.

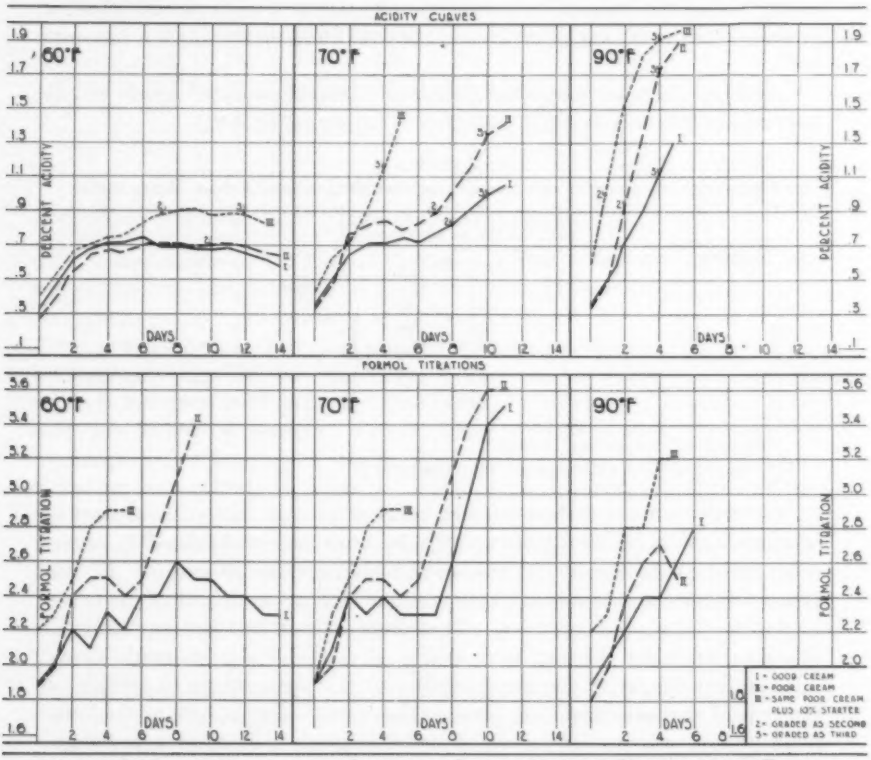

FIG. 1. EFFECT OF TEMPERATURE, QUALITY OF CREAM, AND ADDED STARTER ON THE TITRATABLE ACIDITY AND FORMOL TITRATION OF CREAM.

The three charts in the upper half of Figure 1 show the rates of development of acidity in three of the samples of cream held at 60, 70, and 90° F. The solid lines designated by Roman numerals I, show the trends of acidity at the indicated temperatures in a split sample of cream produced and handled under careful conditions; the dash lines, labeled II, show the rates of development of acid in sweet cream of poor quality. The dotted lines labeled III refer to acidity curves for the same cream as II except that 10

per cent of butter culture was added prior to incubation. The Arabic numerals (2 and 3) indicate the time at which the cream was classed as second and/or third grade.

A study of the acidity curves shows several interesting facts.

1. At 60° F. the acidity of the poor cream (II) increased only slightly more rapidly than that of the good cream (I). The maximum acidity of approximately 0.7 per cent was attained by the fourth day and was maintained thereafter without further increase. The acidity of the cream to which starter was added (III) increased steadily for 8 days to approximately 0.9 per cent.

2. At 70° F. there were greater differences in the rates of development of acidity in the good cream, poor cream and poor cream plus starter than were noticed at 60° F. The addition of starter greatly stimulated the rate of acid development and hastened the time when the cream was classed as third grade or illegal cream.

3. At 90° F. the rate of acid development and per cent acidity attained was much greater than at the lower temperatures. The acidities at which the poor cream and the poor cream plus starter were classed as third grade were noticeably higher at high temperatures than for the same cream incubated at lower temperatures.

4. A general study of all three graphs points out clearly the importance of temperature of storage on the rate of development of acid in cream, its effect in magnifying the differences between good and poor cream especially after the second day of storage, and the fallacy of establishing a fixed maximum acidity as the line of demarcation between first and second or second and third grade cream.

pH Determinations. The data for the pH determinations show in a general way the same points as are demonstrated in the acidity curves and for this reason they are not presented in tabular or graphic form. The hydrogen ion concentration of the cream decreased rapidly during the first 2 days to a value of about pH 4.6 and then continued to decrease at a slower rate as might be expected from a study of the acidity curve of the same sample. The pH values afforded less information about the condition of the sample than the acidity curves, due to the fact that the pH dropped quickly to a minimum during the first few days of storage then showed little change thereafter.

Formol titrations. The three charts at the bottom of Figure I show the results of formol titrations on the same samples for which acidity curves are presented at the top of the figure. On the assumption that the formol titration reflects the extent to which proteins have been broken down into simpler components, particularly amino acids, the following observations may be made from the curves presented in Figure 1.

1. At 60° F. the rate and amount of protein decomposition was less in

the good cream (I) than in the poor cream II, and the addition of starter (III) accelerated proteolysis.

2. At 70° F. there is a noticeable parallelism between the formol titration curves and the corresponding acidity curves in the upper part of Figure 1.

3. At 90° F. proteolysis as revealed by the formol titration was accelerated at about the same rate as the acidity.

4. The differences in the rate of proteolysis in the poor cream (II) and the good cream (I) is more marked at the lower temperatures than at the higher.

5. The addition of starter tended to stimulate proteolysis at all temperatures of storage and the effect was noticeable from the beginning of the storage period.

Yeast and mold counts. In Figure 2 the logarithms of the yeast counts and of the mold counts have been plotted for one of the sets of samples. At 50° F. there was little, if any, growth of yeasts or molds. At 60° F. there were a maxima of 100 yeasts and 100 molds per ml. (log. = 3) in 6 and 8 days, respectively. At temperatures of 70, 80, and 90° F. the growth of these forms was definitely stimulated. The graphs in Figure 2 confirm the statement commonly made by creamerymen that any cream not refrigerated during the warm months of the year may become yeasty after the second or third day.

DISCUSSION

Observations made on a large number of cream samples has given some indication of the time required for cream to become second and third grade when held at various temperatures from 50° F. to 90° F. inclusive. By actually tasting and grading the cream daily some knowledge has been gained regarding the nature of the off flavors which predominate in the cream at any particular time. Because of the variations in the original quality of the cream and the microbial flora present it is impossible from the above data to state definitely how long cream will remain first grade or second grade.

The prolonged holding of cream at low temperatures (below 60° F.) does not result in the development of high acidities, regardless of the original quality of the cream. Undesirable off flavors, such as stale, bitter, and unclean, will eventually appear and result in a second grade cream. Under these conditions the producer may minimize the importance of frequent deliveries and proper sanitary methods; however, attention to both is essential if a high quality cream is desired. Cream of good sanitary quality held on the farm, at 65° F. or below should remain first grade for at least one week. Two weeks' storage may result in third grade cream.

Since facilities for holding cream at 65° F. or below are not available on many farms, it is imperative that the strictest attention be paid to careful production and frequent marketing. Off flavors appear in the cream early

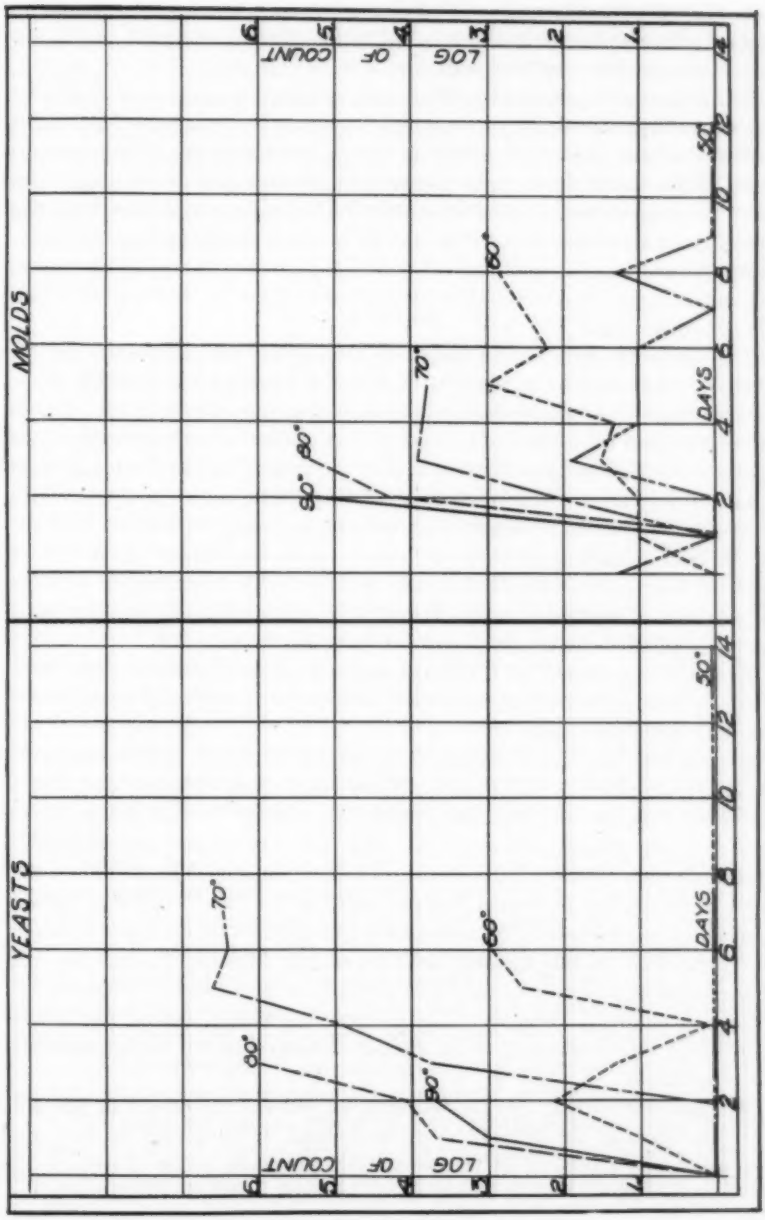

FIG. 2. EFFECT OF TEMPERATURE ON RATE OF GROWTH OF YEAST AND MOLDS IN CREAM.

in the storage period because a 70° F. temperature is favorable for bacterial growth. By keeping the bacteria out of cream, the bad effects of the higher storage temperature may be lessened to a certain degree.

The undesirable effects of holding cream at high temperatures is clearly demonstrated by the rapidity with which the cream becomes second and third grade and by the seriousness of the off flavors which appear. The injury to cream which results from high storage temperatures may be minimized by use of the evaporation method of cooling. It may be possible by lowering the temperature of the cream 10 to 15° F. to delay the formation of yeasty, cheesy, bitter, rancid, and unclean flavors. The marketing of cream at frequent intervals is advised if conditions necessitate the holding of cream at high temperatures.

The results showing the per cent acidity in cream when it became second or third grade, indicate the possible fallacy of applying a fixed acidity as an index to grade. A rather definite parallelism existed between the storage temperature and the acidity of the cream when classed as second grade. The higher the storage temperature the higher the acidity at the time of change in grade from first to second or from second to third grade.

At the lower storage temperatures the differences in the rate of development of acid in good cream and poor cream were not great, but at 70° F. or above the poor cream showed definitely more rapid development of acidity. The addition of starter to cream increased the rate of development of acid and also shortened the time required for cream to be degraded.

The daily determination of the hydrogen-ion concentration of cream held at various temperatures yielded little information not already revealed by total acid determinations.

Results with the formol titrations showed an apparent relationship with the acid development in the cream. These observations suggest that either the formol titration may be influenced by the acidity, or that the presence of the acid may stimulate proteolysis. The fact that the addition of starter to cream accelerated the rate and amount of acid development, increased the formol titration, and decreased the time required for the cream to be classed as second or third grade by organoleptic methods lends strong support to the assumption that in this instance acid tended to stimulate proteolysis. It has been rather generally agreed that proteolytic processes are retarded by increase in acidity. However, it is common knowledge among the cream graders that many defects of cream such as cheesiness await the development of high acidities.

The assumption that the formol titration reflects the extent of protein decomposition may be defensible on theoretical grounds, but it does not necessarily follow that all of the proteolytic processes which contribute to high formol titration values are of an undesirable character. This conclu-

sion is supported by the fact that the early fermentation products of a good butter culture improve the flavor of butter and at the same time the acid may accelerate proteolysis.

If the formol titration value is increased in cream by a commonly accepted practice such as the addition of starter, one should exercise caution in concluding that the formol titration always reflects an undesirable condition. Until the limitations of the formol titration have been established by determining the parallelism between these values and the actual quality of the cream for buttermaking, it would be advisable to withhold strict interpretation of the index value of the test.

SUMMARY

The results may be summarized as follows:

1. When cream was held at 50° F. it changed from first to second grade in from 11 to 16 or more days. At 70° F. it changed in from 3 to 10 days, and at 90° F. in from 1 to 4 days. The time required for the cream to change from first to third grade varied from 4 to more than 16 days as the temperature was varied by 5° intervals between 50 and 90° F.

2. The cream soured in from 1 to 6 days, souring more rapidly as the storage temperature increased. Stale flavors were most prevalent at low storage temperatures after several days (4–14) holding. Putrid flavors were detected at high or low temperatures but not at intermediate temperatures (60–75° F.). Bitter flavor varied widely in time of appearance (1–14 days) but apparently was retarded at low temperatures. Unclean flavor appeared early. Rancidity was not detected in cream stored at 50 to 55° F. but appeared in from 3 to 9 days at other storage temperatures. With one exception cheesy flavor appeared only at temperatures of 65° F. or above. Yeastiness appeared in from 4 to 5 days at temperatures of 85 and 90° F., but as storage temperatures were reduced development of this flavor was retarded.

3. At the lower storage temperatures (50 and 60° F.) the cream was regarded as second grade at lower levels of acidity than when the cream was stored at higher temperatures. At 60° F. the acidity of poor cream increased only slightly faster than that of good cream, the maximum being 0.7 per cent in 4 days and remained the same thereafter. At 70 and 90° F. the rate of acid development in the poor cream was much greater than in the good cream, the rate of acid development being dependent on the storage temperature. Addition of starter to poor cream increased the rate of acidity development at all temperatures, being greatest at the higher temperature.

4. The hydrogen-ion concentration of the cream decreased rapidly during the first 2 days to a value of pH 4.6, after which the rate of decrease was less. The pH values revealed little information not indicated by tests for total acidity.

5. Formol titrations of cream held at 60° F. indicated that protein decomposition was less in good cream than in poor cream. At higher storage temperatures proteolysis was accelerated, but the difference between the rate in poor and good cream was more marked at lower temperatures. Addition of starter to poor cream caused an increase in the formol titration at all temperatures. Data presented raises a question regarding the validity of the formol titration as an index of undesirable conditions.

6. Practically no yeasts or molds developed in cream held for 16 days at 50° F. At temperatures of 70° F. or above mold and yeast development increased rapidly.

REGULATING THE FEEDING OF CERTAIN ROUGHAGES TO MINIMIZE THEIR INFLUENCE ON THE FLAVOR OF MILK

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INTRODUCTION

Most roughages have been shown to cause flavor in milk when appreciable quantities are consumed by dairy cows within one to five hours before milking (1). The general recommendation has been to withhold from cows all flavor produceing feeds such as clover and alfalfa during the five hour period before milking. It is recognized that if superb flavored milk is to be produced, such a procedure is necessary. The general milk supply at present, however, is not produced according to this standard. The experiments reported in this paper were designed to arrive at a feeding procedure that would not be burdensome and expensive for the dairyman to carry out and yet would make it possible for him to produce milk with a flavor that would be acceptable to the average consumer.

EXPERIMENTAL

Source of the Milk: A college herd of 19 cows was used in the different feeding trials. The herd consisted of fifteen Jerseys, three Holsteins and one Ayrshire. All of the cows were registered pure breds and were producing milk which was normal in flavor. The cows were milked by machine and the milk was cooled immediately after milking by being passed over a brine external tubular cooler. The samples used for scoring were taken as composites from the milk of the entire herd.

Scoring the Milk: The milk samples were scored as unknown by four judges. In order to satisfy the requirement for statistical analysis that bias be removed from the experiment, the "unknowns," consisting of controls and experimental samples, were placed in random order for scoring.

The controls consisted either of composite milk samples taken from the herd when no roughage was fed during the five hour period before milking as described under Regime 1, or of samples taken from the morning milking after the cows had consumed an average of 0.8 pound of alfalfa hay during the five hour period before milking. The average flavor score when all roughage was withheld during the five hour period before milking was 22.85, and was 22.70 when an average of 0.8 pound of alfalfa hay was consumed during this period. The score card used was that of the American Dairy Science Association (2) which allows 25.00 points for a perfect score. In accord with the general custom in the use of the score card, a score of 23.00

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was considered an average for milk that could not be criticized as having a flavor defect.

The milk was heated to a temperature of approximately 100° F. for scoring.

The flavor scores were subjected to statistical analysis and conclusions are based on this analysis.

Feeding Regimes: The experiment was divided into eight feeding regimes as indicated in table 1. The concentrate ration mentioned in the descriptions of the feeding regimes consisted of eight parts rolled barley, two parts beet pulp, two parts coconut meal and one part cottonseed meal. Such a mixture, when fed one or two hours previous to milking, has been found not to materially affect the flavor of milk (1). In regimes 2, 3, 6, and 7 "free access to alfalfa hay" means that a fresh supply of alfalfa hay was placed in the feeding racks twice daily before the cows were removed from the milking stable following milking. The hay was thus available to them immediately after milking.

TABLE 1

Average flavor scores of milk produced during the different feeding regimes

FEEDING REGIME	FEED CONSUMED DURING FIVE-HR. PERIOD BEFORE MILKING (POUNDS)	NUMBER OF SAMPLES	NUMBER OF SCORES	AVERAGE FLAVOR SCORE
1. Control, no roughage during five hour period before milking; concentrates fed before milking.		8	29	22.85
2. Free access to alfalfa hay. Concentrates fed before milking. Corn silage fed after milking.	Alfalfa, a.m. 0.8# Alfalfa, p.m. 3.8#	38	150	22.61
3. Free access to alfalfa hay. No concentrates or corn silage fed.	Alfalfa, a.m. 2.4# Alfalfa, p.m. 4.0#	8	29	22.65
4. Free access to alfalfa pasture during day time between milkings.		10	32	21.99
5. Free access to alfalfa pasture both day and night		6	24	22.45
6. Free access to alfalfa hay. Concentrates and corn silage fed before milking.	Corn silage, 14.2#	10	40	22.23
7. Free access to alfalfa hay. No concentrates fed. Corn silage fed at milking time.	Corn silage, 18.9#	6	24	21.83
8. Free access to Sudan grass pasture during day between milkings.		6	24	22.55

RESULTS

The data (Table 1) show that when the cows were given free access to a fresh supply of alfalfa hay immediately after milking in feeding regime 2, a very small amount of the hay was eaten during the five hour period before the morning milking, and a somewhat larger amount was consumed in the five hour period before the afternoon milking. The flavor score indicates that the flavor of the milk produced during this regime was not quite equal to that produced when all roughage was withheld during the five hour period prior to milking as in regime 1. The flavor, however, was considered to be acceptable for ordinary market milk purposes. Roadhouse and Henderson (1) have previously shown that five pounds of alfalfa hay fed two hours before milking, produced a distinct and undesirable feed flavor in milk and that the average flavor score was 22.00. Ten pounds of alfalfa hay fed two hours before milking produced a strong, undesirable feed flavor in milk and the score was reduced to an average of 20.50.

When the herd was pastured on alfalfa during the interval between the morning and afternoon milkings, the flavor score was affected seriously enough to justify the practice of removing the cows from the pasture a sufficient time previous to milking to avoid objectionable feed flavor in the milk. When the cows were pastured on alfalfa both day and night, the flavor score was not seriously affected. This result is interpreted to mean that when the cows had access to alfalfa pasture twice a day they consumed their requirements for roughage in the first hours on pasture and that they did not consume sufficient feed in the later hours to seriously affect the flavor of the milk. The authors (1) have shown that ten pounds of green alfalfa fed two hours before milking caused a distinct and undesirable feed flavor in milk with the flavor score averaging 22.00. This is approximately the score of the milk produced during feeding regime 4 when the cows were pastured on alfalfa during the day only.

In feeding regime 6, corn silage was fed at milking time. An average of 14.2 pounds per cow was consumed and the flavor score of the milk averaged 22.23. In regime 7, concentrates were not fed and the cows consumed an average of 18.9 pounds with the flavor score being reduced to an average of 21.83. In this case the flavor was distinct and was considered to be undesirable in market milk. When such amounts of corn silage are fed it should be given after milking if good flavored milk is to be produced. The authors (1) have previously shown that as little as five pounds of corn silage fed one hour before milking caused an after-flavor in the milk but not a distinct feed flavor.

When the cows had free access to Sudan grass pasture during the interval between the morning and afternoon milkings, the flavor of the milk was not considered objectionable and the flavor scores averaged 22.54.

The average flavor score of the judges for the milk produced during each

feeding regime and the average score of the four judges for the milk produced during the eight feeding regimes were analyzed for significance by Fisher's method of mean squares (3). The analysis shows that there was no significant difference between the scores of the individual judges since $F = 2.04$, which is less than the value of 3.07 required for significance according to Snedecor's tables (4). The value of mean squares between feeding regimes of 7.00 is highly significant since $F = 3.66$ for significance (4). This corresponds to Fisher's 1 per cent point. From this analysis it is concluded that the differences between the feeding regimes as measured by the average flavor scores were real and hence can be used in evaluating the effect of the different feeding regimes on the flavor of milk produced.

TABLE 2

Average milk flavor scores of the four judges

TREATMENT	JUDGES				AVERAGE SCORE OF FOUR JUDGES
	A	B	C	D	
1	22.70	22.93	22.83	22.93	22.85
2	22.65	22.85	22.40	22.55	22.61
3	22.56	22.56	22.74	22.74	22.65
4	22.16	22.10	21.90	21.80	21.99
5	22.86	22.62	22.14	22.19	22.45
6	22.58	22.50	21.83	22.00	22.23
7	21.83	22.33	21.58	21.58	21.83
8	22.25	22.50	22.90	22.50	22.55

DISCUSSION

The results reported in the present study indicate that the college herd, when given the opportunity to consume their roughage requirements immediately after milking, did not return to the feed racks later and consume enough feed during the five hour period before milking to seriously affect the flavor of the milk.

Statistical analysis indicates that the differences in the flavor scores of the milk produced on the eight feeding regimes were significant. Regimes 4 and 7 are regarded as being definitely detrimental to the flavor of milk. Feeding regime 6 was also detrimental, but it was not as objectionable as when the larger quantity of corn silage was fed. The other feeding regimes are considered satisfactory as a practical feeding procedure to minimize the influence of feed on the flavor of milk.

It is to be emphasized that if sufficient quantities of flavor-producing feeds are consumed by cows within four or five hours prior to milking, feed flavor will be present in the milk. The feeding regimes that did not affect the flavor seriously were arranged so that the cows consumed the greater part of their roughage requirements during the first hours after milking.

SUMMARY AND CONCLUSIONS

A herd of nineteen cows was maintained on eight different feeding regimes and the milk produced during these periods was scored by four judges. The following conclusions are drawn:

1. When the cows were receiving alfalfa hay as roughage and were given the opportunity of consuming their roughage requirements immediately after milking, they did not return to the feed racks and consume sufficient hay in the five hour period before milking to seriously affect the flavor of the milk.

2. When the cows were given access to alfalfa pasture both day and night for the entire interval between milkings they did not consume sufficient feed during the last five hours before milking to seriously affect the flavor of the milk. When they were given access to the pasture only during the interval between the morning and evening milkings, they consumed sufficient feed during the five hour interval before milking to cause an objectionable feed flavor in the milk. Under these conditions it is recommended that the cows be removed from the pasture four or five hours before milking if feed flavor in the milk is to be entirely avoided.

3. Pasturing the cows on Sudan grass during the interval between the morning and evening milkings, did not cause an objectionable flavor in the milk.

4. Corn silage in an average amount of 18.9 pounds per cow, fed previous to milking, caused a distinct and undesirable feed flavor in the milk. An average of 14.2 pounds per cow was less detrimental to the flavor but was considered objectionable. If large amounts of corn silage are used in the ration it is recommended that it be fed after milking.

5. When the results were subjected to statistical analysis no significant difference was found between the scores of the different judges. The differences in the regimes were found to be highly significant and corresponded to Fisher's 1 per cent point.

ACKNOWLEDGMENTS

Acknowledgment is made to the Division of Animal Husbandry for the care and management of the animals used in this experiment, and especially to Dr. G. H. Hart and Professor W. M. Regan for their assistance in judging the samples of milk.

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ABSTRACTS OF LITERATURE ON MILK AND MILK PRODUCTS

BACTERIOLOGY

366. The Presence of Mastitis Streptococci in Bovine Mammary Tissue. G. J. HUCKER, N. Y. State Agr. Exp. Station, Geneva, N. Y. Conven. Intern. Assoc. Milk Dealers, Production Section, p. 87, 1936.

Udders of 23 cows which had passed through at least one lactation period and showed no traces of chronic mastitis were removed and handled aseptically. A member of the bovine mastitis streptococcus group was isolated from every udder. The conclusion is drawn that all cows which have passed through one or more lactation periods carry mastitis streptococci as a normal inhabitant of the udder. If the above conclusion is later confirmed then more emphasis will be placed upon individual resistance than upon eliminating actively infected cows from the herd. E.F.G.

367. Bang's Disease Control. L. J. THOMPKINS, Sheffield Farms Co., New York City. Conven. Intern. Assoc. Milk Dealers, Prod. Section, p. 99, 1936.

The successful use of calfhood vaccination for Bangs' disease is reported. E.F.G.

368. The Sterilization of Glassware. K. A. TRISH, Chief, Food and Sanitation, Dept. of Health, Kenosha, Wis. Ice Cream Trade J. *33*, 4, p. 27, April, 1937.

A method was devised for checking the efficiency of the sterilization process used by restaurants and taverns. An ordinary test tube, containing a small, tightly wound cotton swab made on a wire the end of which extends through the cotton plug of the tube was used. To this tube 2 cc. of a normal saline solution was added and the tube and contents sterilized by autoclave for 20 minutes at 15 pounds pressure.

When collecting samples, the inspector removes the cotton plug, takes out the moist swab and carefully wipes the inner and outer rim of the cup or glass approximately one inch down, using a slow, gentle rotary motion and trying to cover the same amount of surface of each glass with the same number of strokes. The swab is then replaced in the tube and the tube gently shaken. Upon arrival at the laboratory, 1 cc. of the solution is plated out on nutrient agar, incubated for 48 hours and colonies counted. The elapsed time between collection and plating does not exceed two hours.

Two samples are collected at each establishment visited, and at the time the inspector notes any existing conditions which might affect the sterilizing process, checks the strength of chlorine solution, if chlorine is used, or the

temperature of rinse water where hot water is used. Establishments are rated on their bacterial counts, classifying those with counts of 1–10 as excellent; 11–30 as good; 31–50 as fair; 51–100 as poor; and over 100 as very poor.

Statistics covering a period from 1929 to 1937 were presented which indicated the number of establishments which were rated as good. Restaurants had a much higher percentage rate as good than did the taverns. High counts were usually traceable to an inadequate supply of hot water or improper strength chlorine rinse solution. W.H.M.

369. Limitations of the Direct Microscopic Count of Bacteria in Milk. E. G. HASTINGS, Dept. of Agr. Bacteriology, Univ. of Wis. Milk Dealer *26*, 8, p. 100, May, 1937.

The author discusses the limitations of the direct microscopic count of bacteria in milk. It is pointed out that the method, while theoretically quite ideal, in reality has very distinct limitations and unless these are recognized, the judgment concerning the milks to which the method is applied is likely to be erroneous. C.J.B.

BUTTER

370. Cooked Butter (Ghee). W. RITTER. Schweiz. Milchzeitung 12, 1936.

The writer discussed the manufacture of and the qualities of cooked butter (Ghee), which has become a general article of trade in Switzerland since about a year ago. The differences between cooked butter and butterfat obtained by mere separation from the aqueous parts at a low temperature are discussed. The latter does not present the aroma of cooked butter; it becomes colorless when heated and is less able to resist the development of tallowy flavor than cooked butter, which becomes slightly brown when heated. Probably the difference between these two kinds of butter rests in the fact that the cooked butter contains small amounts of lecithin. A slightly rancid taste or other undesirable tastes are removed by cooking the butter as housewives are wont to do for a long time (steam distillation). The mere separation of fat from aqueous parts at a low temperature has not the same effect.

The use of hydroquinone is discussed as an antioxidant against the development of tallowy flavor. A specific smell of fish-oil is produced by heating butterfat with certain amounts of hydroquinone at increased temperatures. A short mention is also made about the influence of copper and iron on the quality of Ghee, the antioxidizing effect of lecithin and the experiences made in controlling the quality of cooked butters offered for sale. W.R.

371. Some Practical Procedures for Testing Sediment in Cream. S. L. TUCKEY, Univ. of Ill., Urbana, Ill. Nat. Butter and Cheese J. *27*, 10, p. 6, May 25, 1936.

Four proposed methods of testing for sediment in cream and butter were

submitted by the American Association of Creamery Butter Manufacturers in a national survey. Procedures are described and preliminary results from 31 laboratories are tabulated. W.V.P.

372. How to Judge Butter. L. C. THOMSEN, Univ. of Wis., Madison, Wis. Nat. Butter and Cheese J. *27*, 10, p. 8, May 25, 1936.

Principles of butter judging and scoring are explained. Tables are given to show deductions for certain flavor and body defects. W.V.P.

373. California's Shrinkage Problem with Mid-West Butter. F. ABBOTT, Sec'y. California Creamery Operators Association, Davis, California. Nat. Butter and Cheese J. *27*, 12, p. 18, June 25, 1936.

If leakiness of butter purchased by California distributors in middle western states is not eliminated, other sources of supply will have to be found. W.V.P.

374. California's Butter Labeling Act—and Factors Leading to Its Adoption. FRED H. ABBOTT, Univ. of California, Davis, Calif. Nat. Butter and Cheese J. *27*, 23, p. 6, Dec. 10, 1936.

The Butter Labeling Act in California, which is the result of a quality improvement campaign, has resulted in a greater demand for first quality butter and better prices for producers of high-quality cream. W.V.P.

375. How to Manufacture; How to Determine Butter of Good Keeping Qualities. J. A. NELSON, Montana State College, Bozeman, Montana. Nat. Butter and Cheese J. *27*, 23, p. 36, Dec. 10, 1936.

Keeping quality of butter depends on the cream, factory sanitation and manufacturing. It can be determined by scoring each churning of butter, holding a sample for 7 days at 70° F. and then rescoring. W.V.P.

376. Factors Relating to the Keeping Quality of Butter. O. R. OVERMAN, Dept. of Dairy Husbandry, Univ. of Ill., Urbana, Ill. Nat. Butter and Cheese J. *27*, 24, p. 6, Dec. 25, 1936.

A summary is given of the results of a five-year study of the keeping quality of 36 lots of butter during a two-year storage period at 0° to – 10° F. Records were kept of physical and chemical constants, rates of oxidation and methods of manufacture. The best keeping quality was found in unsalted butter churned from fresh cream separated from fresh, sweet, whole milk. W.V.P.

377. Distribution and Costs of Steam, Electrical Power, and Labor in Representative Idaho Creameries. D. R. THEOPHILUS, HOBART BERESFORD, AND J. L. BARNHART. Depts. of Agr. Eng. and Dairy Husb.

Data secured in a detailed study of the distribution and costs of steam,

electrical power, and labor in two representative Idaho creameries established many interesting facts. Among the most salient facts were: Atmospheric roller driers used 65 to 80 per cent of the total steam generated; 1.4 pounds of steam were required to dry 1 pound of liquid milk; 8.8 pounds of steam were required to pasteurize 100 pounds of cream; straight-away can washers required more steam and power per 100 cans washed than rotatory washers; steam, electricity, and labor averaged respectively 28.3, 13.4, and 58.2 per cent of the total energy cost of manufacturing butter; steam, electricity, and labor averaged respectively 78.5, 9.1, and 12.3 per cent of the total energy cost of manufacturing milk powder; labor represented 70.9 per cent of the total energy cost of manufacturing ice cream.

D.H.N.

CHEESE

378. Making Cheese from Pasteurized Milk. S. L. TUCKEY, Dept. of Dairy Husbandry, Univ. of Ill., Urbana, Ill. Nat. Butter and Cheese J. *27*, 23, p. 22, Dec. 10, 1936.

Pasteurization of milk for cheesemaking is discussed from the standpoints of health, cheese quality, industrial reaction, and manufacturing and economic problems. W.V.P.

CHEMISTRY

379. Development of the Lactochrometer. H. H. TUCKER, N. J. Agr. Exp. Sta., New Brunswick, N. J. Conven. Intern. Assoc. Milk Dealers, Prod. Section, p. 42, 1936.

The depth of yellow color in milk is measured by measuring the depth of a layer of milk required to absorb an equal amount of blue and violet wave lengths as are absorbed by a standard plate. A reading of 10 is used when no milk remains for the light to pass through and a reading of 0 is used when 10 millimeters of milk are required. E.F.G.

380. Testing Milk and Cream. D. H. NELSON. Circ. 340, California Agr. Exp. Station, 12 figs., 1937.

This circular describes the approved procedure for the simplest tests for the quality of milk and cream. With these directions the tests should be successfully performed by persons not familiar with milk testing or with laboratory technique. The tests described include the Babcock test for fat, the Mann's test for acidity, the lactometer method for solids, and the sediment test for extraneous matter. D.H.N.

381. The Detection of Copper in Milk and Cream by Means of the Peroxydase-reaction. Schweiz. Milchzeitung 91, 1935.

It has been known for some time that the presence of copper in milk is apt to produce a positive Storch-reaction in high temperature pasteurized

milk, which may give the impression that pasteurization has not been sufficiently high. The author avails himself of this fact for the detection of copper in cream dissolved by keeping the milk in a kettle of copper before it is centrifuged. The formation of indo-phenol-dye by means of H_2O_2, dimethyl-p-phenylendiamin-sulphate and α-naphthol is recommended as a reaction fitted for the purpose. The cream must be shortly heated at 85° C., in order to kill the milk-enzyme. The reaction takes place after a period of 2 minutes up to 2 hours. It is weakened by a too high or a too prolonged heating. Experiments show the presence of copper in milk after one pumping or straining the latter through a brass sieve. The reaction does not take place in sour cream.

This way of detecting a cream that has come into contact with copper is easier and surer than the aldehyde-reductase (xanthine-oxidase) test or the tasting for tallowiness of the cream submitted to holding pasteurization and then cooled for 24 hours. W.R.

382. The Detection of Copper in Butter and Butterfat by Means of the Peroxydase-Reaction. W. Ritter. Schweiz. Milchzeitung No. 91, 1935.

A simple test for the detection of increased quantities of copper in butter and butterfat consists in heating at 85° C. and cooling again 2 grams of butter in 10 cc. of fresh milk which has not come into contact with copper. Afterwards the peroxydase-reaction with dimethyl-phenylendiamin-sulphate, α-naphthol and H_2O_2 is carried out with the emulsion. The presence of increased quantities of copper is shown by a quicker appearance of the blue coloring. The reaction is disturbed by the presence of somewhat important amounts of peroxides which are formed while tallowy flavor is developing in butter and other fats. The presence of peroxide can be detected by carrying out the reaction with copper-salt instead of H_2O_2. This very simple reaction corresponds in its chemism to other rapid tests and is well adapted for determining the assimilation of copper by fats not yet spoiled. W.R.

FOOD VALUE

383. The Nutritive Value of Milk. John L. Rice, Comm. of Health, New York City. Abn. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 69, 1936.

A summary of some of the outstanding nutritive qualities of milk. E.F.G.

834. Milk Gains Recognition as Important Source of Vitamin C. Editorial. Milk Dealer *26*, 7, p. 49, April, 1937.

The National Dairy Council summarizes the work on pasteurization reported by Cornell University and Kansas State College. The following

points are of interest and importance to the dairy industry: (1) The vitamin C content of milk is relatively constant throughout the year, (2) it is commercially feasible to pasteurize milk by the holder method and maintain essentially as high a vitamin C content as that of raw milk at the same age. C.J.B.

385. Chemical Sterilization on the Farm and in the Plant. F. E. A. SMITH, The Diversey Corp., Chicago, Illinois. Nat. Butter and Cheese J. *27*, 15, p. 34, Aug. 10, 1936.

Effective sterilization of dairy equipment with chlorine solution depends upon thorough cleaning of equipment; the use of proper amounts of solutions of correct strength; and upon complete contact of solution with equipment. Three general groups of chlorine sterilizers are described and directions for using them are given. W.V.P.

386. Factors Involved in Making Milk More Palatable. JAMES MARSHALL FRAYER, Univ. of Vermont, Burlington, Vt. Milk Dealer *26*, 7, p. 42–, 98–, April, 1937.

A discussion is given of the factors affecting the flavor of milk. Abnormalities in milk classified according to their origin into five groups—(1) physiological disturbance, (2) feed, (3) bacterial, (4) chemical, and (5) absorbed—the author presents a complete review of the literature pertaining to each class. C.J.B.

387. Fluid Milk Market Stabilization in Wisconsin. F. SCHULTHEISS, Comm., Wis. Dept. of Agr. and Markets. Milk Dealer *27*, 7, p. 44, April, 1937.

A detailed discussion and explanation of the Wisconsin fluid milk market stabilization law is presented. C.J.B.

388. Current Trends in Milk Consumption; Nov. 1936—Jan. 1937. EDWARD FISHER BROWN, Milk Research Council, Inc., New York City. Milk Dealer, *27*, 7, p. 90, April, 1937.

The author gives a comprehensive report of the performance of the fluid-milk market in metropolitan New York, Boston, and Philadelphia during the period Nov., 1936, to Jan., 1937. C.J.B.

389. The Significance of Bacterial and Chemical Changes Occurring in Mastitis Milk. L. A. BURKEY, E. B. MEIGS, G. P. SANDERS AND J. F. CONE. Bureau of Dairy Industry, U. S. Dept. of Agr., Washington, D. C. Conven. Intern. Assoc. Milk Dealers, Prod. Section, p. 67, 1937.

It is believed that the percentage of chlorides, the presence of large numbers of the infecting organism and the loss of rennet curdling proper-

ties are the most significant changes helpful in the identification of mastitis through milk examination.

General observations upon attempts to experimentally induce mastitis through careless handling and rough milking practices indicate that the prevalence of high percentages of mastitis among dairy herds may be due as much to poor milkers and rough or extreme use of milking machines as to the spread of the infecting organisms. E.F.G.

390. Mastitis and Carbohydrate Deficiency. GEORGE W. CAVANAUGH, Cornell Univ., Ithaca, N. Y. Conven. Intern. Assoc. Milk Dealers, Prod. Section, p. 45, 1936.

That mastitis may be due to carbohydrate deficiency in the ration of the cow is suggested as a possibility by Fr. Wiedmann of the Research Institute of the Agricultural Control Station at Regensburg. Carbohydrate deficiency in the ration results in decreasing content of milk sugar and increasing content of sodium chloride in order to maintain normal osmotic pressure. With the salt rise the reaction changes and the germicidal property of the milk and udder disappears. A medium is formed that is most favorable for the growth of bacteria and mastitis develops because of decreased germicidal property. E.F.G.

391. Composition of Milk as Affected by Sub-clinical Mastitis. A. C. DAHLBERG, J. J. KUCERA, J. C. HENING, AND G. J. HUCKER, N. Y. Agr. Exp. Sta., Geneva, N. Y. Conven. Intern. Assoc. Milk Dealers, Prod. Section, p. 54, 1936.

It is concluded that the degree of infection of a herd with sub-clinical mastitis has no significant effect upon the composition of herd milk. Only when the infection becomes acute do changes of importance occur in the chemical composition of the milk. E.F.G.

392. Modern Merchandising—What Is It and How Does It Apply to the Milk Industry? RUSSEL J. DAVIS, Harrison, N. Y. Milk Dealer *26*, 8, p. 80, May, 1937.

The author insists that unless at least 50 per cent of the trade of any milk business can be attributed to the efforts of the routeman, the company is vulnerable to progressive competition. Ten ways to help the routeman are given. C.J.B.

393. Electric Sterilization of Dairy Utensils. J. M. BRANNON, Univ. of Ill., Urbana, Ill. Milk Dealer *26*, 8, p. 112, May, 1937.

Data are presented showing the energy consumed, bacterial counts per pail before and after sterilization, and the effect of the sterilized utensils on bacterial content of milk when using electric sterilization. The author concludes that the advantage the electric sterilizer has over other methods is convenience. C.J.B.

394. Some Factors Affecting the Properties of Whipping Cream and the Quality of the Finished Product. W. S. MUELLER, M. J. MACK, AND H. G. LINDQUIST, Dept. Dairy Industry, Mass. State College, Amherst, Mass. Mass. Agr. Exp. Sta., Bul. 335, Nov., 1936.

A mechanical whipper of constant speed was used for whipping the cream. Relative stiffness was determined by measuring with a sensitive wattmeter the input of the whipper motor in watts at intervals of five to ten seconds throughout the whipping process. The relative whipping ability of the cream was determined by comparing the average watt increase in stiffness per second of whipping time. Other properties studied were viscosity, overrun, and serum drainage.

Whipping temperatures above 40° F. for 36 per cent cream reduced the maximum stiffness and the overrun and increased the serum drainage of the whipped cream.

Cream separated from milk at 90° F. had slightly better whipping qualities than that separated at 100° F.

Standardizing cream, using skim milk or whole milk, whether before or after pasteurization gave no significant difference in the whipping ability of the resulting cream.

Pasteurizing cream at temperatures from 145° to 165° F. had little effect on whipping ability. Aging whipping cream longer than 24 hours had no practical advantages.

Cream containing 30 per cent butterfat is satisfactory for whipping.

Adding serum solids in the form of skim milk powder and plain condensed skim milk slightly decreased the whipping ability and serum drainage. The viscosity of the cream increased as the serum solids content was raised, and the plain condensed skim milk was more effective than the powdered skim milk in this respect. The benefits derived from increasing the serum solids content of 30 per cent fat cream to 11 per cent were not great enough to justify the procedure.

Adding 10 per cent cane sugar appeared to give sufficient sweetness to the whipped cream. Sugar up to 15 per cent may be added any time after the first minute of whipping without any detrimental effect. Adding sugar before pasteurization or immediately before whipping are the least desirable times for adding the sugar.

Homogenization at 500 to 1500 pounds pressure, running through a colloid mill, hand homogenizing, and delayed cooling of cream after pasteurization had no beneficial effects on the whipping ability of cream.

Partial freezing of milk (13 per cent) prior to separation and partial freezing of cream (50 per cent) either before or after pasteurization had no significant effect on the whipping qualities of the cream. Total freezing of cream after pasteurization was only slightly detrimental while total freezing of cream before pasteurization destroyed the whipping properties of the cream.

The use of Kraftogen, dehydrated sodium caseinate, Dariloid, gelatin, vegetable gelatin, dehydrated egg albumin and dehydrated egg yolk were studied and their effect on whipping cream is discussed, but since it is not legal in many places to use these substances the practice in general cannot be recommended. H.G.L.

395. The Trade-Ways Survey of Retail Salesmanship and Route Supervision in the Milk Industry. CARROLL Y. BELKNAP, Trade-Ways, Inc., New York City. Ann. Conven. Intern. Assoc. Milk Dealers, Sales and Advertising Section, p. 21, 1936.

Instances are cited to show the difference between effective and indifferent methods of selling milk by route salesmen. E.F.G.

396. Developing More Effective Salesmanship. ROBERT L. BUCKINGHAM, Trade-Ways, Inc., Chicago, Ill. Ann. Conven. Intern. Assoc. Milk Dealers, Sales and Advertising Section, p. 39, 1936.

Two points are covered: I. Route men can be made effective as salesmen; II. Route men need and want real selling help. The New I. A. M. D. training program and use of the manual will soon be available. E.F.G.

397. Quality Milk as a Sales Leader. STUART PEABODY, The Borden Co., New York City. Ann. Conven. Intern. Assoc. Milk Dealers, Sales and Advertising Section, p. 46, 1936.

An exceptionally high grade of milk, as certified, or some other premium milk will call attention to your product in a favorable manner and provide a distinctive selling point. E.F.G.

398. How a Well-Regulated Credit Division Can Assist Sales. A. J. CRAMER, Borden's Farm Prod., New York City. Ann. Conven. Intern. Assoc. Milk Dealers, Sales and Advertising Section, p. 62, 1936.

It is possible for the credit division to so handle many difficult accounts that these customers are retained and the accounts made profitable. E.F.G.

399. How to Develop Selling Methods to Meet Changing Conditions. WILL A. FOSTER, Vice-President, Borden's Dairy Delivery Co., San Francisco, California. Ann. Conven. Intern. Assoc. Milk Dealers, Sales and Advertising Section, p. 82, 1937.

Changed dietary habits due to the machine age have presented problems for the milk industry. Selling methods are classified. E.F.G.

400. Between Meal Milk Service in Industry. ETHEL AUSTIN, Martin National Dairy Council, Chicago, Ill. Ann. Conven. Intern. Assoc. Milk Dealers, Sales and Advertising Section, p. 116, 1936.

A survey of 83 factories employing 115,000 persons in which more than

⅓ had employed milk service for 10 years or longer showed an overwhelming sentiment in favor of the service. Methods of approach in order to initiate this service are discussed. Details of the service to make it most effective such as responsibility, method, time of day, products and safety measures are outlined. E.F.G.

401. What the Milk Industry Is Doing to Build Consumer Confidence. F. J. KULLMAN, JR., Chairman, Public Relations Committee, I. A. M. D. Ann. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 24, 1936.

The film, The Milk Parade, and the presentation of the Pasteur medals were emphasized. E.F.G.

402. A Glimpse of the Dairy Industry Abroad Today. FRED F. LININGER, Penn. State College, State College, Pa. Ann. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 28, 1936.

Price control and consumer cooperatives in Great Britain, Sweden, Finland, Germany, and Russia are discussed. E.F.G.

403. The Approach to and Results of 1936 Legislation. W. A. WENTWORTH, Sec. Dairy Industry Committee, Washington, D. C. Ann. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 43, 1937.

A summary of state and national legislation affecting the milk industry. E.F.G.

404. How Can Public Good-Will Be Safeguarded for the Dairy Industry. WILLIAM B. DURYEE, Secretary for Agr., State of New Jersey, Trenton. Ann. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 59, 1936.

Numerous ways are discussed by which the milk industry can build consumer confidence and an appreciation of the value of the service which the modern milk distributor performs. E.F.G.

405. Modern Merchandizing—Can Milk Dealers Do It. G. LYNN SUMNER, Pres. G. Lynn Sumner Co., New York City. Ann. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 96, 1936.

The dairy industry with greatest single food and health product in the world is too modest. A discussion of the application of advertising to the milk industry. E.F.G.

406. What We Saw at the Dairy Machinery Exhibit. E. N. MUZZY, Carnation Co., Seattle, Washington. Ann. Conven. Intern. Assoc. Milk Dealers, Plant Section, p. 52, 1936.

The 1936 Dairy Industries Exposition Exhibits of new equipment are

discussed and described by the Messrs. Muzzy, Nourse, Goldsmith and Leudicke. E.F.G.

407. Report of the Simplified Practice Committee. A. H. LEUDICKE, Chairman, Ann. Conven. Intern. Assoc. Milk Dealers, Plant Section, p. 81, 1936.

A report is made upon:

1. Tolerance for stainless steel tubing.
2. Sanitary fittings.
3. Flanged fittings.
4. Standardizing design of small cans.

E.F.G.

408. Treatment of Milk Wastes—American and European Practice. A. M. BUSWELL, Chief, Illinois State Water Survey, Urbana, Ill. Intern. Assoc. Milk Dealers, Plant Section, p. 107, 1936.

Dairy wastes are divided into 3 classes: (1) cooling water, (2) utensils and floor washing, and (3) by-products, as skim milk, buttermilk and whey. The use of trickling filters, activated sludge method and treatment of the waste in closed tanks under anaerobic conditions is discussed. The latter is recommended for class 3 wastes. E.F.G.

409. Lowering the Milk Bottle Costs. R. B. SOLTZ, Ohio State University, Columbus, Ohio. Ann. Conven. Intern. Assoc. Milk Dealers, Plant Section, p. 113, 1936.

The plan operated by the Columbus Milk Dealers Assoc. by which the members of that Association obtained between 60 and 70 trips per bottle is described. This consisted essentially of preventing junk dealers handling milk bottles and educating the housewife as to the value of a milk bottle. E.F.G.

410. Oxidative Changes in Milk, Cream and Butter. W. RITTER. Mitt. Lebensmitteluntersuchung and Hygiene *26*, p. 145, 1935.

Fishy and tallowy flavors of butter as well as the development of tallowy flavor in milk and cream under the influence of copper and iron are discussed. Allusion is made to the importance of heating and after-treatment of the milk and to the influence of antioxidants (hydroquinone, metol, ascorbic acid) and bacterial activity. Milk from certain cows can become tallowy without coming into contact with metals and the influence of copper, of holding pasteurization and of bacterial activity on the aldehyde-reductase (xanthine-oxidase) of cow's milk are discussed. W.R.

411. The Influence of Copper and Bacterial Activity on the Aldehyde-Reductase (Xanthine-Oxidase) of the Milk. Landwirtschaftl. Jahrbuch der Schweiz, p. 873, 1935.

The aldehyde-reductase (xanthine-oxidase) of raw milk, as indicated by

the reduction time of a mixture of formaldehyde and methylene blue, is not essentially influenced by adding small amounts of copper in form of copper sulphates (up to 2 milligrams of copper for 1 liter of milk). The reduction time is not prolonged much by holding pasteurization. The influence of copper is somewhat intensified if this metal is added to milk after holding pasteurization. It is very strong if the copper is added to the milk before holding pasteurization is applied. Pieces of copper or copper-alloys (bronze, brass, German silver) produce similar reactions. If milk or cream are treated with bacteria before they are submitted to holding pasteurization in the presence of copper, the detrimental influence of the latter is considerably weakened. A certain parallel is established between the influence of copper on the aldehyde-reductase (xanthine-oxidase) and that on the development of tallowy flavor in milk; both influences being obstructed in a similar way by bacteria. Different conflicting phenomena make it possible to employ the reaction for the detection of traces of copper in milk or cream. The use of other aldehydes or coloring matters offers no advantage on that of formaldehyde and methylene blue. W.R.

412. Protecting a New Source of Profits for the Milk Dealer. E. F. HRUBY, Eze-Orange Co., Chicago, Ill. Milk Dealer *26*, 8, p. 47, May, 1937.

The author points out the necessity of concerted effort by milk dealers to fight those evils militating against their profit in the chocolate and fruit drink business. C.J.B.

413. History of Pasteurization. JAMES A. TOBEY. Milk Dealer *26*, 8, p. 52, May, 1937.

A brief but detailed history of pasteurization is given. C.J.B.

414. A Dentist Looks at the Milk Business. BION R. EAST. Milk Dealer *26*, 8, p. 74, May, 1937.

Charts are presented showing the trend in per capita consumption of whole milk and cream with that for evaporating and condensed milk, for the year 1931 through 1935. The author concludes that present trends would seem to indicate that the whole-milk distributor must attempt to meet at least the nutritional claims of his evaporated competitor if he hopes to elude the shadows cast by decreasing whole-milk consumption. C.J.B.

415. Bulk, Packages and Novelties. O'NEAL JOHNSON, Statistical and Accounting Bureau, Intern. Assoc. Ice Cream Mfgrs., Ice Cream Trade J. *33*, 4, p. 20, April, 1937.

Reports from 300 plants representing 44,000,000 gallons of frozen products have been compiled. Sales trends during the ten year period 1925 to

1935 indicate a percentage decrease in the sale of bulk ice cream and an increase in the percentage sales of novelties and specialties, cups, and packages. Bulk sales decreased from 88.23 per cent in 1935 to 58.56 per cent in 1935. The sale of specialties in 1935 was over six times the amount sold in 1926, according to the Census Bureau report. Only one grade packaged ice cream was manufactured by 74.70 per cent of the plants and 16.87 per cent reported that they made two grades of packages. In regard to overrun 9.84 per cent reported overrun percentages greater in packages than bulk, 47.54 per cent reported the same overrun and 42.62 per cent reported a lower overrun in packages. Fifty-one per cent of the manufacturers sold packaged ice cream for a higher price than bulk, and the percentage selling it for the same price or a lower price was practically the same in both cases. Reasons for selling packaged ice cream were—because of competition, consumer demand, dealer demand, advertising possibilities, and to make possible the sale of two grades of ice cream. In the large cities the linerless direct fill brick package seemed to be the most popular type of package. Round cylinder type package was regarded as best for many manufacturers.

W.H.M.

416. Controlled or Dealer Outlets? C. O. KEENE, Miller Ice and Dairy, Cambridge City, Ind. Ice Cream Trade J. *33*, 4, p. 17, April, 1937.

Advice to the wholesaler of ice cream given by the author of this article is "make better salesmen and merchandisers of your accounts by teaching them how to make a good profit on ice cream sales and by teaching and working with them on store set-ups in order that a more desirable atmosphere will result. If your dealer is shown how he can make money on his ice cream and soda fountain sales, he will immediately give your merchandise the space and attention it deserves in his store and an immediate increase in volume will be your reward." To the operator of the various types of retail stores he says, "concentrate your efforts more in the operation of your store proper. Teach your clerks more about salesmanship and proper merchandising methods; devise some practical method by which leaks will immediately be detected; and demand that the gross you know can be had is in the cash register at the close of every business day." W.H.M.

417. The Trend in Trucking Costs. R. E. SLONAKER, Phila. Dairy Products Co., Inc., Philadelphia, Pa. Ice Cream Trade J. *33*, 4, p. 35, April, 1937.

The number of stops, gallons of ice cream sold, and the cost of delivery for 1932 and 1935, for three plants, each using a different type of delivery system, is given in the following table.

	Plant 1 Peddle System		Plant 3 Call System	
	1932	1935	1932	1935
Ave. No. of stops per route	39	36	61	58
Ave. No. gallons per route	68	74	232	210
Ave. No. miles driven	50.4	58.6	58.8	56.4
Cost of delivering per gallon	18.05	13.9	6.75	7.32

The type of delivery system used will depend on area served. The call system will work satisfactorily in the larger metropolitan areas and the peddle system seems better adapted to the smaller cities and towns.

The increase in packaged goods and novelties experienced by most plants has decreased the pay load and tended to increase trucking costs. On the other hand, mechanical cabinets have made it possible to increase the length of routes and cover more territory. Today a 1½ ton truck with mechanical refrigeration will carry as much pay load as a 5 ton truck would 10 or 15 years ago.

For all plants covered by this report the average number of gallons per route was 132 daily in 1932 and 161 in 1935. The 1932 delivery cost was 9.56 per gallon compared with 8.19 in 1935. Most of the saving was effected by change in the size and type of delivery equipment. W.H.M.

418. Ice Cream Sales for 1936 Show Increase of 22.26 per cent over 1935. O'NEIL M. JOHNSON, Ice Cream Trade J. *33*, 5, p. 29, May, 1937.

Ice cream sales in every state of the union in 1936 were higher than for 1935. The increase ranged from 7.77 per cent in Kentucky to 46.00 per cent in Tennessee and an average of 22.26 per cent for the entire United States. These figures were based on reports received for members of the International Association of Ice Cream Manufacturers which represents more than half the total production reported by the Bureau of Agricultural Economics. W.H.M.

419. State Standards for Ice Cream—How Far Might They Go? HARRY KLUETER, Wisconsin Dept. of Agr. and Markets. Ice Cream Trade J. *33*, 5, p. 32, May, 1937.

The history and development of ice cream standards from the time of their inception up to the present time in the United States and in various states is described. W.H.M.

420. Wedding Cakes for Blushing Brides in the Marry Month of June. P. J. Smith, Ice Cream Trade J. *33*, 5, p. 25, May, 1937.

Directions are given for making and decorating a simple and double tier ice cream cake. W.H.M.

421. Ice Cream Regulation Must be Extended. R. G. Ross, Dept. of Health, Tulsa, Okla. Ice Cream Trade J. *33*, 5, p. 26, May, 1937.

Any ordinance covering ice cream or frozen desserts must be a part of or closely associated with a milk ordinance, as it would be impossible to enforce the former unless the latter was properly enforced. W.H.M.

422. Milk Products in the Mix. P. H. TRACEY, Univ. of Ill., Urbana, Ill. Ice Cream Trade J. *33*, 5, p. 27, May, 1937.

In a paper presented at the University of Illinois short course for ice cream makers the author has outlined the important points to be considered in the selection of the various milk products commonly used in the manufacture of ice cream. W.H.M.

423. What Do Consumers Think? H. P. SMITH, Univ. of Ill., Urbana, Ill. Ice Cream Trade J. *33*, 5, p. 35, May, 1937.

This paper deals with the information obtained from 200 customers of the University of Illinois milk route who were asked several questions pertaining to ice cream. W.H.M.

424. Regulatory Standards and Methods of Manufacturing Ice Cream. WILLIAM B. PALMER. Ice Cream Trade J. *33*, 5, p. 40, May, 1937.

Mr. Palmer, chairman of the Committee on Milk and Dairy Products of the American Public Health Association, discusses the recommendations made by his committee for the promotion of the work. W.H.M.

425. Proper Processing of the Mix to Make Good Ice Cream. W. J. CORBETT, Univ. of Illinois, Urbana, Ill. Ice Cream Trade J. *33*, 4, p. 29, April, 1937.

Directions are given for mixing and processing the ice cream mix. The importance of weighing ingredients, the order of adding the ingredients to the pasteurizer, neutralizing excess acid, pasteurization temperatures, homogenization and aging are some of the topics discussed. W.H.M.

426. Using Fruits, Nuts, and Candy as Flavoring for Ice Cream. R. J. RANSEY, Sealtest System Lab., Inc., Cleveland, Ohio. Ice Cream Trade J. *33*, 4, p. 37, April, 1937.

Recommendations are made regarding the amounts, varieties, and manner of adding various kinds of flavoring material to ice cream. W.H.M.

427. Factors that Must Be Considered in Selecting the Mix Standard. P. H. TRACY, Univ. of Ill., Urbana, Ill. Ice Cream Trade J. *33*, 4, p. 38, April, 1937.

An analysis is given of the various factors which must be considered by the ice cream manufacturer in determining the composition of his ice cream.

In the selection of a formula consideration must be given to state regulations, the type of milk products and equipment available, the type of competition his ice cream must meet, the effect of the proposed combination of solids upon the quality and freezing operations, and the cost of the mix. Tables are presented to show the effect of texture score of ice cream made from mixes of varying fat and serum solid content, the relation of overrun to shrinkage in dipping, the relation of mix composition to the mix cost and the cost per gallon of mix for each of the solids used. W.H.M.

428. Painting and the Elimination of Bacteria and Fungus. MILTON W. LIGHTCAP, Maintenance Service Dept., Pittsburgh Plate Glass Co., Pittsburgh, Pa. Nat. Butter and Cheese J. *27*, 10, p. 26, May 25, 1936.

Three essential steps must be taken to provide maximum sanitation in food manufacturing plants: abundance of light, absolute cleanliness, and the use of paint designed to inhibit growth of bacteria and fungi. W.V.P.

429. Cutting Refrigeration Bills with Natural Cooling Without Ice. R. M. WASHBURN. Nat. Butter and Cheese J. *27*, 17, p. 6, Sept. 10, 1936.

Methods of supplementing mechanical refrigeration in creameries with "natural cold" in winter are summarized. Fairly successful methods of cooling water for use in the plant include the use of an underground cistern in combination with a cooling tower; a system of pipes on the north side of the building for cooling water for the compressor; circulation of water through steel barrels; a series of sprays in outdoor tanks; and underground tanks far enough below the frost line to prevent freezing. The Washburn method uses the best features of the other systems and consists of a pre-cooler combined with a deep underground tank of three compartments.

W.V.P.

430. What Can An Association Accomplish for the Benefit of the Industry. WILLARD L. SIMMONS, Ice Cream Trade J. *33*, 5, p. 17, May, 1937.

The author discussed the activities of trade associations and their value to individual members. W.H.M.

431. Data Compiled by the Census Bureau Record Changes in the Industry. Anonymous. Ice Cream Trade J. *33*, 5, p. 17, May, 1937.

The distribution of sales for 2,465 plants in 1935 and 3,150 plants in 1929 when compared show the trends and important changes which have occurred during this period. A decrease in the percentage of sales to their own wholesale branches, to industrial users, to wholesalers and jobbers, to

retailers, and to household consumers is indicated. Sales to their own retail stores increased from 4.7 per cent in 1929 to 10.7 in 1935.

Distribution expense amounted to 22.8 per cent of net sales, 9.8 per cent of which was for payrolls. Of the 13,119 employees 1,718 were females.

W.H.M.

432. Getting the Most Effective Results from Plant Refrigeration Systems. L. C. THOMSEN, Univ. of Wisconsin, Madison, Wis. Ice Cream Trade J. *33*, 5, p. 23, May, 1937.

Information and data which should be helpful to prospective operators of refrigeration machinery are presented. Vertical single-acting machines are usually preferred by small to medium size dairy plants. These machines generally have a bore to stroke ratio of unity, *e.g.*, $4'' \times 4''$, $5'' \times 5''$, etc. By varying the speed intermediate capacities are readily attainable. Where large installations are necessary, the single- or double-acting horizontal machines have found favor. With this type of machine it is possible to operate at dissimlar suction pressures. In a plant where considerable low temperature work is desired, a two-stage machine may have a distinct advantage. These installations are usually found in plants with a rated capacity in excess of 50 tons. The rated tonnage of a compressor may be calculated by using the following equation:

$$\frac{\pi r^2 \times L \times N \times C \times V}{8.15 \times .42} = \text{Rated tonnage}$$

Where
$\pi = 3.1416$
r = radius of cylinder, in feet
L = length of stroke of piston, in feet
N = number of strokes of piston per minute
C = number of cylinders
V = Volumetric efficiency in percentage

The vertical shell and tube type and the enclosed horizontal shell and tube type are increasing in popularity. Conservation of water may also be accomplished by passing the condenser water through the water jacket of the compressor and then used as boiler feed water. The unit type of cooler is becoming more popular for refrigeration room cooling. The finned type expansion coil is satisfactory although the air circulating unit type cooler with or without special circulating ducts is claimed to result in better temperature and humidity control as well as increased efficiency.

Other recommendations included are: the use of galvanized or rustless expansion piping, insulation of expansion lines, use of thermometers in expansion piping and condensers for the purpose of checking temperatures, and the correct installation of thermometers and gauges. Directions are also given for connection of the refrigeration line to direct expansion and continuous freezers and pressures used in the operation of this equipment. For the hardening room 9 to 12 linear inches of 2-inch diameter expansion

pipe will suffice for each cubic foot of space. Where it is desired to use the flooded system, the accumulator on the outside should be placed as high above the room as possible and its drain should be well insulated. In the flooded system 1 pound of ammonia per foot of 2-inch piping is required.

In the case of milk plants desiring to manufacture flake or brine ice, special machines have been built for this purpose. W.H.M.

433. Are You Adequately Insured? CLARENCE T. HUBBARD. Ice Cream Trade J. *33*, 4, p. 25, April, 1937.

The centralization of insurance responsibilities for analysis and supervision with one competent source, and a review of all insurance contracts and problems periodically are recommended. A list of standard insurance available to ice cream manufacturers is given and important points to consider in the selection of insurance discussed. W.H.M.

434. The Necessity of Sound Accounting Methods under Present-Day Conditions. STUART C. MCLEOD, Sec. Nat. Assoc. of Cost Accounts, New York City. Ann. Conven. Intern. Assoc. Milk Dealers, Gen. Sessions, p. 64, 1936.

The application of accounting to the milk industry is discussed with particular reference to new developments including the Robinson-Patman Act and social security legislation. E.F.G.

435. Generated vs. Purchased Power. RALPH COPP, Pevely Dairy Co., St. Louis, Mo. Ann. Conven. Intern. Assoc. Milk Dealers, Plant Section, p. 3, 1936.

Cost figures are given for plant investment and operation of Diesel and steam units operated under various conditions. E.F.G.

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A totally enclosed continuous flow method of Pasteurizing milk that meets the requirements of all Health regulations. The holding period is accurately governed by positive automatic gears that cannot be changed. Milk must be held for a minimum of 30 minutes or dumped on the floor.

With either the JUNIOR unit, for plants of small or medium capacities, or the larger unit for plants of large capacities, the milk is not in view from the time it enters the weigh tank until it appears in the bottle. There can be no plant contamination during the processing period.

Made in capacities of from 2,500 to 30,000 pounds per hour in tinned copper or stainless steel and priced as low as is consistent with dependable machinery.

Catalogues will be cheerfully mailed on request, without obligation. Please state the capacities you are interested in.

STANDARD MILK MACHINERY CO.
(INCORPORATED)
LOUISVILLE KENTUCKY

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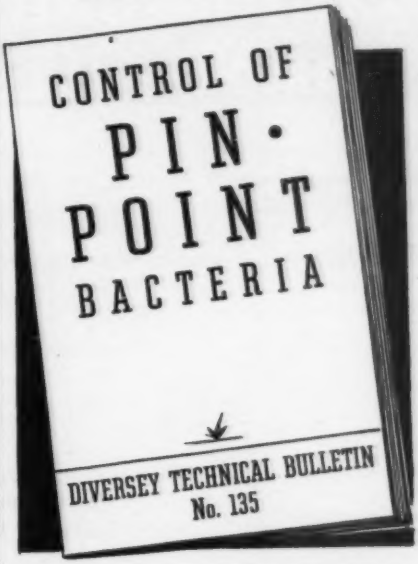

RECENT research work has shown that "pin-point" bacteria in many cases survive ordinary heat sterilization. In the subsequent pasteurization, they find temperature conditions ideal for rapid multiplication. Not only is the bacteria count seriously increased by such bacteria . . . but sometimes these bacteria are responsible for off-flavors in the pasteurized milk supply.

Kills Bacteria by Contact

Control of "pin-point" bacteria should not be left to chance. Independent laboratory tests have shown that the control of these bacteria is most effectively accomplished through sterilization of utensils and equipment with Diversol. Even in cold water, Diversol quickly and completely destroys bacteria by contact.

Furthermore . . . Diversol is the only quick-acting sterilizer that is non-corrosive. It is easy to use . . . dissolves instantly, completely. Keeps its strength indefinitely.

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The Diversey Corporation
53 W. Jackson Blvd., Chicago

Gentlemen: Without obligation please send Technical Bulletin No. 135 "The Control of Pin Point Bacteria."

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MARSCHALL

RENNET *and* COLOR

for cheese manufacture

are uniformly strong and pure, hence always dependable. Up-to-date methods and exact control of production insure the quality of Marschall's.

Liberal samples of Marschall preparations for class work or experiment may be had for the asking.

Marschall Dairy Laboratory
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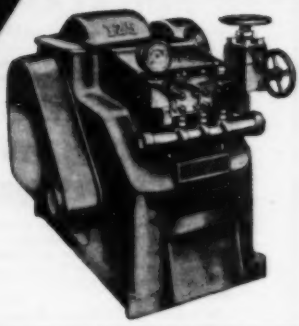
MANTON-GAULIN TWO STAGE HOMOGENIZER



The most Sanitary Homogenizer available, mechanically dependable and unusually efficient. The two stage valve of course for controlled Viscosity and greater uniformity.

The Manton-Gaulin Manufacturing Co.
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MODERNIZE
Your Plant *with* a
WESTFALIA
No Foam Separator

- No Foam on Skim or Cream even with elevation of both
- Large Sludge Room, therefore Long Runs without Shut-down
- Higher Skimming Efficiency
- Lower Cost of Operation
- Greater Simplicity of Construction
- *Ask for Catalog.*

We also carry a full line of **No Foam Clarifiers and Standard Separators.** **Model MDD**

WESTFALIA SEPARATOR CO., INC.
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Media Specified in Methods and Standards FOR CERTIFIED MILK
(1937)

BBL DESOXYCHOLATE AGAR

BBL Desoxycholate Agar is the approved medium for the enumeration of organisms of the coli group in *Certified Milk.*

BBL DEXTROSE EXTRACT AGAR

BBL Dextrose Extract Agar was tested extensively by the Committee on Methods and Standards of the A.A.M.M.C. In comparison with Standard Nutrient Agar the BBL Dextrose Extract Agar gave considerably higher counts. This medium has been especially prepared for and approved by the A.A.M.M.C. for the enumeration of total bacteria in *Certified Milk.*

Literature and prices sent on request.

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No Oxidized Flavors from Stainless Steel

All parts of this "truly sanitary" pump, coming in contact with milk, are stainless steel. Made in four sizes. Prices complete with totally inclosed motor **$60.00** to **$175.00.**

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Supreme in Stainless Steel

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The leadership of Mixevan for quality is the result of over 30 years specialized experience. Its uniform character is achieved through expert knowledge, individual selection of beans, extra development of the bouquet, intricate compounding and special grinding technique . . . *It is the ultimate in fine flavoring for dairy products.*

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Bacto-Violet Red Bile Agar

For the Detection and Enumeration of Coli

Bacto-Violet Red Bile Agar is recommended for the direct plate count of *Escherichia coli* in milk and other dairy products. Upon plates of medium prepared from Bacto-Violet Red Bile Agar colonies of coliform organisms are red and are surrounded by a reddish zone of precipitated bile. Reliable and comparable counts may be made after an 18 hour incubation period.

Bacto-Violet Red Bile Agar is readily made up for use in the laboratory without adjustment of its reaction or filtration of the solution.

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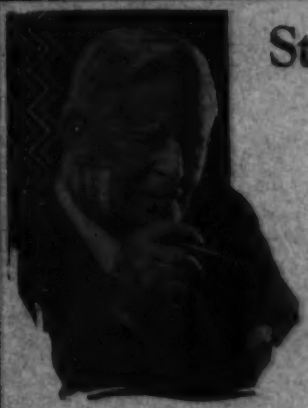

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Improved our

Bacterial Counts

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